Mineral Development Division
Department of Mines and Energy
Government of Newfoundland and Labrador

GEOLOGY, GEOCHEMISTRY AND MINERAL POTENTIAL OF THE ACKLEY GRANITE AND PARTS OF THE NORTH WEST BROOK AND EASTERN MEELPAEG COMPLEXES, SOUTHEAST NEWFOUNDLAND (PARTS OF MAP AREAS 1M/10,11,14,15,16; 2D/1,2, 3 AND 7)

by

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Report 83-6

St. John's, Newfoundland
1983

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Acknowledgements

This work was done under the Canada/Newfoundland Mineral Development Subsidiary Agreement (1976-1982) by contributions from the Government of Newfoundland and Labrador (10 percent) and from the Departments of Regional Economic Expansion (45 percent) and Energy, Mines and Resources (45 percent) of the Government of Canada.

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ABSTRACT

This report describes the geology, geochemistry and mineral occurrences of the Ackley Granite in southern Newfoundland. The Ackley Granite is a post-Acadian intrusion, dated at 355 Ma, which intruded Middle Ordovician metasediments and metavolcanics of the Gander and Baie d'Espoir Groups, and the Late Precambrian metavolcanics and metasediments of the Long Harbour, Love Cove and Musgravetown Groups. The Hermitage Bay - Dover fault, which juxtaposes the Gander and Baie D'Espoir Groups and the Precambrian units, is truncated by the Ackley Granite. Previously mapped parts of the Ackley Granite are shown to be highly deformed granitoids and metasediments unrelated to the Ackley Granite, and are here termed the North West Brook Complex and the Eastern Meelpaeg Complex. These two complexes are probably equivalent, and are separated by 30 km of the Ackley Granite. Both complexes consist of foliated, coarse grained, porphyritic biotite granite and granodiorite, foliated, medium grained, porphyritic to equigranular biotite ± muscovite granite and granodiorite, and foliated to massive, leucocratic muscovite ± garnet ± tourmaline granite with minor high grade metasediments of the Gander and Baie d'Espoir Groups.

The Ackley Granite has seven major phases based on mineralogy and texture. The four northern units (9-12) consist of biotite ± hornblende, microcline-porphyritic granodiorite and granite with one unit containing orthoclase perthite phenocrysts and another containing a muscovite-bearing phase. The three southern units are high level intrusions consisting of coarse grained, biotite granite with Units 13 and 15 being porphyritic and Unit 14 being equigranular. Unit 14 is subdivided into a fine grained porphyritic granite and a more abundant coarse grained equigranular granite. The fine grained phase is located mainly near the southern contact of the Ackley Granite. This phase, which is a late differentiate from the coarser grained granite, is the host of significant molybdenite mineralization in the Rencontre Lake area and contains cassiterite and minor molybdenite mineralization with associated quartz-topaz greisen, southwest of Gisborne Lake.

Geochemical analyses of 800 samples of the North West Brook and Eastern Meelpaeg Complexes and the Ackley Granite were made. The Eastern Meelpaeg and North West Brook Complexes show similar geochemical variations. The coarse grained porphyritic Unit 5 is more potassic but less silicic than the medium grained Units 6 and 7 and is probably petrogenetically unrelated to them. Units 5, 6 and 7 are probably crustal melts with Unit 5 forming at a greater depth than Units 6 and 7.

The northern units (9-12) of the Ackley Granite show linear to curvilinear variation in the abundance of elements when plotted against the Thornton-Tuttle differentiation index (TTDI) which ranges from 63 to 97. The more extensive southern units (13-15) have a much more restricted range of TTDI (85-97) and linear variations in the concentration of elements are less well defined. The southern units are highly silicic (mean >75% SiO_2) with the fine grained marginal phases even more silicic, particularly in the vicinity of mineralization.

The Ackley Granite is an I-type granite which probably formed by anatexis of continental crust. The northern units possibly resulted from greater degrees of partial melting and crystal fractionation than the southern units which have a more restricted chemical variation. Local extreme fractionation of plagioclase and biotite may be the cause of the highly differentiated, finer grained marginal phases with consequent enrichment in Mo and Sn and associated hydrothermal alteration.

INTRODUCTION

The Ackley Granite (Dickson *et al.*, 1980), underlies an area of approximately 3,000 km^2 in southeastern Newfoundland (Map 1). The granite is well known as the host of sizable showings of molybdenite which have been the target of intermittent geological, geochemical, and geophysical surveys for over sixty years. None of the showings is currently considered economic.

PURPOSE AND SCOPE

A reconnaissance lake sediment geochemical survey by Butler and Davenport (1979a) outlined areas of anomalously high trace element contents, particularly Mo, U, and F. The central, southern and eastern parts of the Ackley Granite are high in Mo and U, whereas the northern and western areas are low. Fluorine is particularly high in the Long Harbour-Gisborne Lake area. Prior to this survey, mapping by Bradley (1962), Jenness (1963), Anderson (1965), Anderson and Williams (1971), and Williams (1971), had not subdivided the batholith. The reconnaissance rock geochemical survey by Strong *et al.* (1974) failed to report the presence of various types of granite. Subsequent study of these samples by Whalen (1976) suggested the presence of two main types of massive biotite granite and also areas of deformed granite in areas previously shown as massive granite.

The purpose of the present study is two-fold. Firstly, by carrying out a sampling program on a grid system with a sufficiently small spacing between samples, it should be possible to outline the major granitoid phases within the batholith, and their boundaries. Secondly, random sampling using a grid system permits statistical analysis of petrographic and geochemical data and may allow an assessment of the petrogenesis and economic potential of the granite. Through this study, the exploration significance of the lake sediment anomalies, and their origin, may also be further understood.

Colman-Sadd (written communication, 1978) and Davenport (written communication, 1978) suspected that the western part of the batholith, south of Jubilee Lake, as shown by Anderson (1965), was probably part of the older "southeast equigranular granite" (Colman-Sadd, 1976). Davenport suggested the change in lake sediment geochemistry patterns was due to the change in lithology. Thus the area between Jubilee Lake and the western edge of map sheet 1M/14 was included to determine the boundary between the "southeast equigranular granite" and the Ackley Granite and also to complete a reconnaissance map of the area.

PHYSIOGRAPHY AND DRAINAGE

The area underlain by the Ackley Granite is an extensive plateau which forms part of the Southern Uplands of Newfoundland. The mean elevation is approximately 200 m with a few isolated prominent hills such as The Tolt (290 m) and Mt. Sylvester (381 m). The Ackley Granite is surrounded by much more resistant volcanic, sedimentary, and metasedimentary rocks which form a ridge around the margin of the granite with a mean elevation of approximately 250 m. The plateau dips gently from the northwest to the east and south. Drainage is generally poor with innumerable glacial lakes in till in the northern part of the batholith. The southern part is drained by the Long Harbour River system which has a well developed dentritic pattern and which is locally trellised where affected by jointing in the granite.

Glacial features control much of the drainage pattern. An extensive area of northeast-trending ribbed morraine (see Prest, 1970) in the Meta Pond area, has very poor drainage forming innumerable ponds and small bogs. In the Beaver Brook area, extensive south-southeast trending drumlinoids control the drainage to give parallel streams with numerous consequent streams flowing in at right angles from the drumlinoids.

Drainage in the south of the study area generally flows northwards from the marginal ridge, then swings round to flow into Long Harbour River or Rencontre River and then south to the sea. Drainage in the Bay du Nord River area is generally trellised with the pattern controlled by a generally northeast-trending main tectonic fabric and a weakly developed northwest-trending tectonic fabric. This has resulted in flow to the south-southeast.

The Hermitage Bay fault forms a pronounced depression with small streams and lakes along its length. However, capture of these streams by the Salmon River, Bay du Nord River, and North West Brook has prevented development of a major river system along the fault.

Glacial erratics are generally of local origin, being matched to local bedrock. However, rare exotic blocks were found which indicate that transportation of over 35 km has occurred. For example, a cobble of strongly foliated, porphyroclastic, coarse grained, biotite granite was found at sample locality 012 (Map 1), near the Burin Peninsula highway. The nearest possible source of this rock type is in the Tolt Brook area.

Eskers are common in the southern part of the study area particularly in the Gisborne Lake and Dunns Brook areas. The eskers are commonly meandering and trend towards the south.

A fluvioglacial outwash terrace is well developed near the mouth of the Long Harbour River. The river terrace is about 20 m (63 feet) above sea level (Bradley, 1962) and contains relict oxbow lakes and infilled meanders. Glaciofluvial terraces occur just outside the study area at Tickle Head on Long Harbour, Grand Le Pierre, English Harbour East, and Terrenceville (see Bradley, 1962).

LOGISTICS

This report is based on field work carried out from June 21st to August 24th, 1979. The field base for the project was the town of Terrenceville, which is situated at the northeast corner of Fortune Bay, on the south coast of the island of Newfoundland. The town of Terrenceville is accessible by road (route 211) and is also the terminal for Canadian National Marine coastal boats from ports to the west as far as Port aux Basques. During the summer months, a rapid coastal service for passengers only is available between Terrenceville and Milltown calling at some intermediate communities.

The survey was carried out on foot where the project area is near the main Burin Peninsula Highway (route 210) and by boat where the fiord known as Long Harbour cuts into the southern margin of the granite. The road to English Harbour East reaches within 3 km of the granite contact. The main Bay d'Espoir hydro-electric powerline to the Avalon Peninsula cuts across the central part of the study area. Heavy equipment for the project was brought in by all-terrain vehicles from Swift Current to the east of the project area, by boat and all-terrain vehicle via Long Harbour, and by all-terrain vehicle from Bay d'Espoir. Relief is generally low, ponds are small, and rivers are shallow, so that transportation by tracked vehicle is relatively easy. Only in the Eastern Meelpaeg Lake and Meta Pond area is land access difficult, due to the abundance of larger ponds. However, most of the survey was carried out by utilizing 130 hours of helicopter time. Terrenceville was the base for most of the flying, with the village of Head Bay d'Espoir serving as the base for the western part of the project area.

SAMPLING AND FIELD METHODS

The sampling method used was based on a system devised by Garrett (written communication, 1979). The essential features are that: (1) The proposed map area is divided in 2 km x 2 km squares based on the U.T.M. grid system. (2) Each square is subsequently divided in sixteen squares, one of which is chosen at random. (3) The sample is taken as close as possible to the center of the 0.5 km square. If sampling in that location is unfeasible it may be necessary to move to another 0.5 km square. However, the sample must be from the originally designated 2 km x 2 km square. (4) Replication is carried out when distinct phases or facies of granite are defined, and when there is sufficient outcrop in the area. This results in replication at outcrop, 0.25 km^2, 1 km^2, and 4 km^2 levels for a total of 4 samples from each selected replicated square. A split of the powder, from the sample taken as an outcrop duplicate, gives an estimate of variability at the analytical level. Analysis of variance for the analyzed elements was carried out using the UANOVA program of Garrett and Goss (1980). This indicated that only Ga and La showed more than 50% of the variance at the analytical split level. The difference in Ga and La values between samples at the outcrop and higher levels of sampling is, therefore, meaningless.

Samples were collected using an 8 pound sledge hammer, chisel and geology hammer. Where the outcrop was composed of one rock type, only one sample was taken. Where more than one rock type was present, then each was sampled, where possible, and the dominant rock type noted.

Samples were described briefly in the field and necessary measurements taken, *e.g.* schistosity, strike attitude, size of quartz veins and presence of xenoliths (see Figure 1). Attributes such as grain size, mineralogy, color, etc. were described at base camp using a coded description format (see Figures 2a and b) based on a system by R.G. Garrett of the Geological Survey of Canada.

Gamma radiation was measured at most outcrops using either a Scintrex BGS-1 scintillometer or a Scintrex GIS-4 spectrometer. The scintillometer measures total radiation only, in counts per second (cps). The spectrometer can measure on four channels to give (i) total radiation, (ii) K+U+Th, (iii) U+Th, and (iv) Th. Measurements taken in the field showed that the two instruments gave similar readings for the same locality.

PREVIOUS WORK

The Ackley Granite has been geologically studied at intervals, over a period of 140 years. The earliest reference to granite in this area is from Cormack (1824) who walked across the northern part of the batholith during his journey across the island. He noted the coarse grained porphyritic nature of the granite and named Mt. Sylvester after his Micmac Indian guide.

Most work on the Ackley Granite has been carried out by companies exploring for molybdenite and also assessing the sizable showings in the Rencontre Lake area. The various companies examined the granite - country rock contact from East Bay to the Burin Peninsula. McLachlan (1953) noted that the granite in the Dunns Brook area is different from that found at Ackley City. The "Dunns River Granite" is porphyritic whereas the "Ackley Granite" is generally equigranular.

White (1939, 1940) produced detailed descriptions of the "Ackley Batholith" and molybdenite showings. He also noted the gneissic granite in the Bay du Nord River area and postulated the fault contact between the Ackley Granite and "Bay du Nord Granodiorite" and the gneissic granite to the northwest.

ABBREVIATED FIELD DATA SHEET

No	Fab	Tex	Xen	Gnt	Tourm	Brl	Flour	Remarks

No . . . . Number given sample in field.

Fab. . . . . Tectonic fabric, flow foliation *etc.*, with measurements.

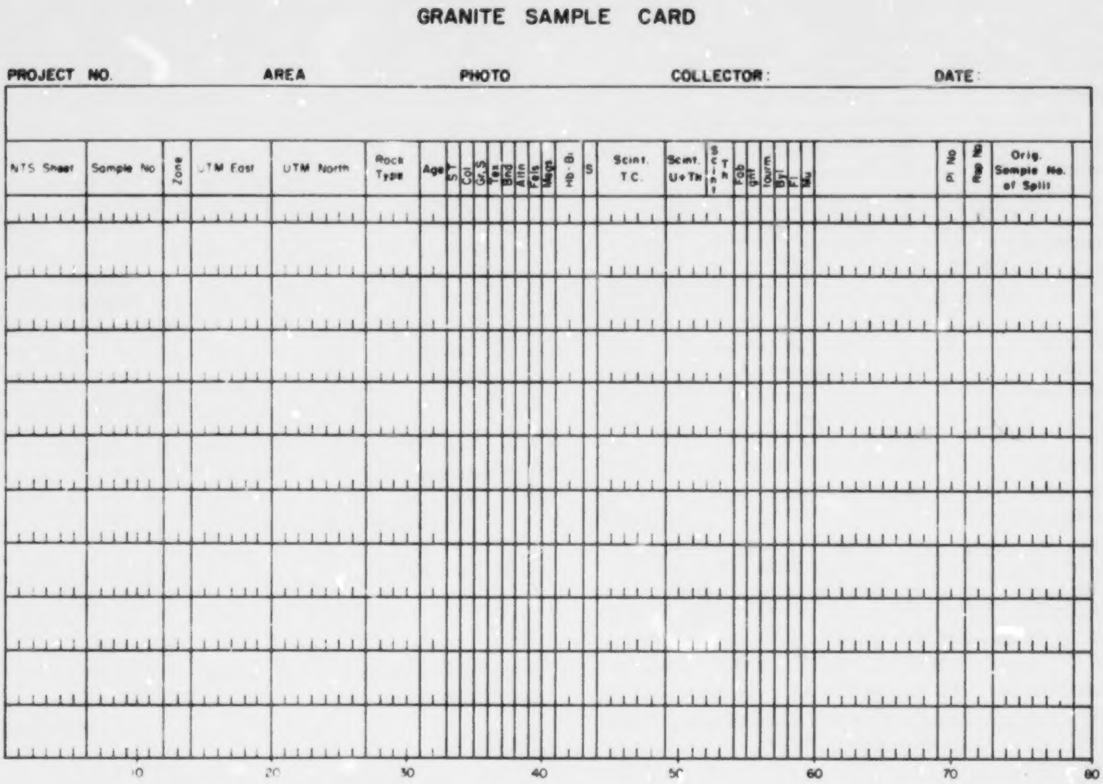
Tex. . . . . Porphyritic, equigranular *etc.*, with proportion of phenocrysts.

Xan . . . . Variety, proportion, shape *etc.*, of any xenoliths in the granite.

Gnt., Tourm., Brl., and Fluor. . . . Garnet, Tourmaline, Beryl and Fluorine - Present or absent; proportion, mode of occurrence, *etc.*

Remarks . . . . any other notes or measurements taken in field *e.g.*, scintillometer readings.

Figure 1: Data sheet used in field during sample collection.



GRANITE SAMPLE CARD

PROJECT NO. AREA PHOTO COLLECTOR: DATE:

NTS Sheet	Sample No	Zone	UTM East	UTM North	Rock Type	Age	ST	Col	Gr.S	Tex	Bnd	Altn	Fels	Mega	Hb-Bi	S	Scint. T.C.	Scint. U+Th	Scint Th	Fab	gnt	tourm	Bxl	Fl	Mu		Pl No	Rep No	Orig. Sample No. of Split	

10
20
30
40
50
60
70
80

Figure 2: *Detailed sample location and description card used to computerize data on granite samples.*

Explanation of Coding Scheme for Granite Sample Card.

COL. 28 - 31

DLMT	Dolomite
LMSN	Limestone
BKSH	Black Shale
SHLE	Shale
SLSN	Siltstone
SNDS	Sandstone
ARKS	Arkose
CGLM	Conglomerate
QRTZ	Quartzite
CHRT	Chert
GRCK	Graywacke
SLTE	Slate
SCHS	Schist
SPDS	Spotted Slate
HRFL	Hornfels
SKRN	Skarn
GRSN	Greisen
QRZD	Qtz. Diorite
GRDR	Granodiorite
QZMZ	Qtz. Monzonite
ALSK	Alaskite
GRNT	Granite
SDCG	Sodic Granite
DORT	Diorite
MNZN	Monzonite
SENT	Syenite
ALKS	Alkali Syenite
QZPP	Qtz. Porphyry
FPPP	Feld. Porphyry
QZFP	Qtz. - Feld. Porphyry
DCIT	Dacite
RDCT	Rhyodacite
RYLT	Rhyolite
ANDS	Andesite
TRCD	Trachyandesite
TRCT	Trachyte
TUFF	Tuff
BSLT	Basalt
DIBS	Diabase
GBBR	Gabbro
SRPN	Serpentinite
VEIN	Vein Material
GNSS	Gneiss
APLT	Aplite

COL. 32 - 33

04	Proterozoic
10	Paleozoic
12	Cambrian
14	Ordovician
16	Silurian
17	Silurian - Devonian
18	Devonian
20	Carboniferous
24	Permian
30	Mesozoic
32	Triassic
34	Jurassic
36	Cretaceous
42	Tertiary

COL. 34

1	Single grab sample
2	Channel sample
3	Composite sample
4	Drill Core
5	Other

COL. 35 - Color

0	White	< 20%
1	White & Black	20-50%
2	Black & White	50-80%
3	Black	> 80%
4	Gray	
5	Green	
6	Buff	
7	Orange or Yellow	
8	Red or Purple	
9	Pink	

COL. 36 - Grain size in mm

0	<0.004	glassy
1	0.004 - 0.025	aphanitic
2	0.025 - 0.062	aphanitic
3	0.062 - 0.250	v.f. grained
4	0.25 - 0.50	v.f. grained
5	0.50 - 1.00	fine grained
6	1.00 - 2.00	med. grained
7	2.00 - 5.00	med. - coarse grained
8	5.00 - 10.0	coarse grained
9	> 10.0	v.c. grained

COL. 37 - Texture

0	Uniform
1	Variable
2	Aplitic
3	Porphyritic
4	Miarolitic
5	Myrmekitic
6	Megacrystic
7	Pegmatitic
8	Other

COL. 38 - Primary features

0	Massive
1	Bedded
2	Crossbedded
3	Slump structured
4	Oriented megacrysts
5	Trachytic

COL. 39

0	Fresh
1	Weathered
2	Gossanous
3	Hydrothermal, white
4	Hydrothermal, rusty
5	Chloritized mafics

COL. 40

0	Feldspars clear
1	Feldspars clouded

COL. 41

0	No megacrysts
1	Feld. megacrysts
2	Qtz. megacrysts
3	Qtz. & Feld. megacrysts
4	Metamorphic porphyroblasts
5	Other

COL. 42 - 43

Hb. & Biot. content of total dark minerals, on scales of 0 - 9. 09 - no hornblende, 90 - no biotite

COL. 44

0	Sulfides absent
1	Sulfides present

COL. 45 - 49

Scintillometer reading of Total counts per second

COL. 50 - 53

Scintillometer reading of U + Th counts per second

COL. 54 - 55

Scintillometer reading of Th counts per second

COL. 55

0	No fabric
1	Cataclastic fabric
2	General tectonic fabric
3	Igneous flow fabric
4	Composite 1 + 2
5	Composite 1 + 3
6	Composite 2 + 3
7	Composite 2 + 2

COL. 56

0	Garnet absent
1	Garnet present

COL. 57

0	Tourmaline absent
1	Tourmaline present

COL. 58

0	Beryl absent
1	Beryl present

COL. 59

0	Fluorite absent
1	Fluorite present

COL. 60

0	Primary muscovite absent
1	Primary muscovite present

COL. 70 - 71

Pluton number

COL. 72 - 73

Replicate number 00 or 01 Used in analysis of variance calculation

COL. 74 - 79

Original sample number of analytical splits

Moore (1953) mapped the contact between the gneissic granite [Garrison Hills Granite of Widmer (1950)] and the Ordovician metasediments to the northwest. However, the contact mapped by Moore was not between the Garrison Hills Granite and the metasediments but between Ackley Granite and metasediments. Wall (1956a,b) carried out a detailed survey in the Western Pond, Medonnegonix Lake, and Kepenkeck Lake areas, in the northwest part of the Ackley Granite. His work forms the basis of information on the southwest contact of the Ackley Granite shown by Anderson (1965).

Bradley (1962) carried out a detailed survey in the Terrenceville to Gisborne Lake area and defined the granite contact and a northerly trending series of roof pendants. Jenness (1963) mapped the northeastern boundary of the Ackley Granite. He correlated the Ackley Granite with similar granites to the north and thus extended the batholith to northern Bonavista Bay. Anderson and Williams (1971) mapped the northwest margin of the Ackley Granite. Williams (1971) mapped the Belleoram map area which includes the southern margin of the batholith between Long Harbour and East Bay.

More recent work includes the rock geochemical survey by Strong *et al.* (1974), a thesis and paper on the Rencontre Lake molybdenite deposits by Whalen (1976; 1980), and uranium determinations by Davenport (1978) on the samples collected by Strong *et al.* (1974).

O'Driscoll and Hussey (1978) and Hussey (1978) mapped and described the eastern margin of the batholith in the Sound Island map area (1M/16).

Butler and Davenport (1979a,b) carried out a lake sediment geochemical survey over the central and southern parts of the batholith.

O'Brien and Nunn (1980) and O'Brien *et al.* (1980a, 1980b), mapped the southern contact of the batholith and the roof pendants in the Gisborne Lake area. Dickson *et al.* (1980), described briefly the various subdivisions of the Ackley Granite and reported on the anomalous gamma radiation in the Long Harbour to Gisborne Lake area. Geochemical analyses, field descriptions, and CIPW norms of samples collected during this project are listed in Colman-Sadd *et al.* (1981).

Detailed maps (1:50,000) and a report which includes the southeastern margin of the Ackley granite (1M/10, 1M/15) will be published in 1983 (O'Brien *et al.*, in press).

RADIOMETRIC AGES

The youngest rocks intruded by the Ackley Granite are the pre-Middle Ordovician metasediments of the Gander Group in the vicinity of Kepenkeck Lake. Contact metamorphic porphyroblasts of cordierite overprint the Acadian cleavage found in the Gander Group and Late Precambrian formations in the Avalon Zone. The Ackley Granite shows only minor alteration of feldspars and ferromagnesian minerals and quartz exhibits a weak undulose extinction. Thus the Ackley Granite post-dates the Acadian Orogeny which is considered to have occurred during the Lower to Middle Devonian in Newfoundland (*e.g.* Williams *et al.*, 1972).

The Love Cove Group is considered to have been deformed during the Acadian orogeny. Schists from the Love Cove Group have been dated (Newfoundland Department of Mines and Energy, 1980) by $^{40}Ar/^{39}Ar$ and the dates obtained (Table 1) are considered to indicate the Acadian metamorphism.

Most dates obtained from the Ackley Granite are younger than the Acadian Orogeny (Table 1). The close agreement

TABLE 1: RADIOMETRIC AGE DETERMINATIONS OF THE ACKLEY GRANITE

LOCATION	METHOD	AGE (Ma)	REFERENCE
Kepenkeck Lake	K-Ar biotite	368 ± 25	Lowdon (1961)
1.6 km northeast of Dunns Brook	K-Ar biotite	392 ± 30	Leech *et al.* (1963)
Medonnegonix Lake	K-Ar biotite	397 ± 16	Wanless *et al.* (1972)
Six separate locations	Rb-Sr whole rock isochron	345 ± 5* 354 ± 8**	Bell *et al.* (1977)
6 km northeast of Dunns Brook	^{40}Ar/^{39}Ar biotite	352 ± 10 355 ± 10	Newfoundland Department of Mines and Energy, 1980
6 km northeast of Dunns Brook	^{40}Ar/^{39}Ar hornblende	356 ± 10	SAME AS ABOVE
Ackley City	K/Ar muscovite	338 ± 7	Whalen (1980)

* 1.47×10^{-11} yr^{-1} - constant used in original paper.

** 1.42×10^{-11} yr^{-1} - constant used in recalculated age in Newfoundland Department of Mines and Energy (1980).

between ^{40}Ar/^{39}Ar hornblende and biotite dates and the Rb/Sr date suggests that the eastern part of the batholith (at least) was emplaced around 355 Ma and cooled rapidly.

The 397±16 Ma K/Ar date from the Medonnegonix Lake area is from a weakly foliated medium grained biotite granite. Thus this older date may give either the age of the granite or the age of deformation of the granite.

GENERAL GEOLOGY

GENERAL STATEMENT

The Ackley Granite underlies an area of approximately 3,600 km^2. The batholith is composed primarily of medium to coarse grained, uniform to porphyritic, massive, biotite granite. Detailed study of thin sections show that the batholith is composed of distinct varieties of granite. However, lack of outcrop prevents precise delineation of contacts. The batholith is clearly intrusive into Late Precambrian rocks of the Avalon Zone and the Middle Ordovician and older sediments of the Baie d'Espoir Group (Colman-Sadd, 1976) and the stratigraphically equivalent Gander Group (McGonigal, 1973). Previously mapped contacts are essentially correct. However, the southwestern margin of the Ackley Granite, between Medonnegonix Lake and Big Blue Hill Pond, has been significantly redefined (*cf.* Anderson, 1965). Also a large area in the northeast previously shown as massive granite (Jenness, 1963), was found to be comprised of various types of foliated granite and metasediments of the Gander Group.

MAJOR SUBDIVISIONS

The granitoid rocks of the map area have been divided into three major units, namely the North West Brook Complex, Eastern Meelpaeg Complex and the Ackley Granite.

The southwestern part of the project area, in the Bay du Nord River area, is composed of strongly to weakly foliated, medium to coarse grained, biotite granite, biotite-muscovite granite, muscovite ± garnet ± tourmaline granite, and coarse grained, porphyritic, biotite ± hornblende granodiorite. This area of foliated granitoids is termed the North West Brook Complex (new name). It is not considered to be related to the Ackley Granite.

In the northeastern part of the map area, a westerly trending zone of various types of foliated granite and metasediment underlies a sizable part of the Ackley Granite as outlined by Jenness (1963). The area contains rocks similar to the North West Brook Complex and is considered correlative. The various granitoids and metasediments are termed here the Eastern Meelpaeg Complex and are not considered to be part of the Ackley Granite. Two isolated areas of deformed granite, which outcrop in the center of the map area, are included in the Eastern Meelapeg Complex.

In the southeast of the map area, the Ackley Granite is capped by a northerly trending series of roof pendants of Precambrian sediments and volcanic rocks (O'Brien *et al.*, 1980b). The roof pendants were originally mapped as Cambro-Ordovician in age by Bradley (1962) but Williams (1971) suggested that stratigraphically equivalent formations are Precambrian and this has been supported by O'Brien *et al.* (1980a; 1980b).

The Ackley Granite has intruded Lower Paleozoic metasedimentary and volcanic rocks of the Baie d'Espoir and Gander Groups to the northwest of the Hermitage Bay-Dover fault. To the southeast of this fault, the granite has cut the Late Precambrian volcanic and sedimentary rocks of the Long Harbour Group and Love Cove Group, sedimentary rocks of the Late Precambrian Musgravetown Group, and Cambrian or older Youngs Cove Group (Williams, 1971).

The Hermitage Bay-Dover fault is the boundary between the Gander Zone to the northwest and the Avalon zone to the southeast (Williams *et al.*, 1972). The Ackley Granite truncates the fault. The North West Brook Complex is bounded to the southeast by the fault. Northwest of the hill known as The Tolt, near the eastern margin of the Ackley Granite, a roof pendant of Precambrian volcanic and sedimentary rocks is in fault contact with intensely fault-brecciated and mylonitized granite. This fault may be a remnant of the originally continuous Hermitage Bay-Dover fault preserved in a roof pendant. The apparent trend of the fault suggests that the roof pendant has been rotated in a counter-clockwise direction from an expected trend of northeast to one of north-northeast, if this fault correlates with the Hermitage Bay-Dover fault.

The metasedimentary rocks (Unit 3) exposed along the northwest, north and northeast contact of the Ackley Granite northwest of the Dover-Hermitage Bay fault belong to the Ordovician Gander Group and equivalent Baie d'Espoir Group. The rocks consist of thin to medium bedded, lower greenschist to amphibolite facies, pelitic to psammitic schists and gneiss with minor metavolcanic rocks. The rocks have been polydeformed during the Acadian Orogeny.

No contacts between the main mass of the Ackley Granite and the Gander and Baie d'Espoir Groups were found. Small, rare, aplite dikes and pegmatites, however, cut the metasediments. The effects of contact metamorphism are conspicuous, however, with commonly developed cordierite and locally andalusite porphyroblasts. The aureole is generally less than 500 m in width. Where granite is not exposed the presence of porphyroblasts in the metasediments has been used to delimit approximately the granite.

For detailed descriptions of various parts of the Gander and Baie d'Espoir Groups in the vicinity of the Ackley Granite the reader is referred to Moore (1953), Berrange and McCabe (1955), Jenness (1963), Swinden and Dickson (1981), and Blackwood and Green (1982).

OTHER PLUTONIC COMPLEXES WITHIN THE MAP AREA

Within the Avalon Zone in the map area, Precambrian rocks are cut by two other plutonic complexes. The Lower Paleozoic Simmons Brook Batholith (Williams, 1971) has intruded Precambrian volcanic rocks of the Connaigre Bay Formation (Widmer, 1950) and is unconformably overlain by the Devonian or earlier Cinq Isles and Pools Cove Formations (Williams, 1971). Williams (*op cit*) described the batholith as consisting of "a variety of pink to gray, medium to coarse grained granite and granodiorite with locally predominant dark green mafic intrusive rocks." Only two localities within the Simmons Brook Batholith were sampled during this project. The outcrops consist of fault-brecciated and foliated hornblende granodiorite. The outcrops are near the Hermitage Bay fault which has caused brecciation and narrow mylonite veins in the granodiorite.

Two small areas of deformed granitoid are found at Pin Hill and at the eastern contact of the Ackley Granite, north of The Tolt. These are tentatively correlated with the Lower Paleozoic and older granitoids of the Avalon Zone. The rock at Pin Hill is a weakly foliated, medium grained, hornblende-biotite monzodiorite and forms a 1 km wide dike which cuts Precambrian rhyolite (O'Brien *et al.*, 1980b). The other area of deformed granitoid, to the northeast, consists of strongly deformed, medium to coarse grained, porphyritic, biotite granite which has intruded strongly deformed, Precambrian volcanic rocks which in turn are cut by cleaved porphyritic diabase dikes.

The other major plutonic unit in the map area is the Cross Hills Granite-Diorite Complex (O'Brien *et al.*, in press) which has intruded the Precambrian Belle Bay Formation and Andersons Cove Formation and is cut by the Ackley Granite. The complex was formerly known as the Cross Hills Batholith (Bradley, 1962; O'Brien and Nunn, 1980; O'Brien *et al.*, 1980a, 1980b).

The Cross Hills Granite-Diorite Complex forms an approximately 250 km^2 body north of the head of Fortune Bay. Another pluton of 30 km^2 occurs 17 km west-northwest of Terrenceville, with a 4 km^2 subsidiary just to the east of it.

The complex consists of gabbro, diabase, granodiorite and granite. During this project only a few outcrops of the complex near the contact with the Ackley Granite were sampled. These outcrops consist of medium grained diabase and coarse grained metagabbro and are not representative of the great variety of rocks found within the complex. The following description is slightly modified from O'Brien and Nunn (1980).

The main body is a complicated mixture of roof pendants, xenoliths, and intrusive rocks. The pendants and accidental xenoliths consist of well bedded sandstones with some siltstones, conglomerates, feldspar porphyritic or glassy rhyolitic volcanic rocks, and diabase with rare gabbro. Xenoliths of intrusive origin are dominant. The sedimentary and volcanic xenoliths are cut by diabase dikes with chilled margins. Diabase is commonly the only rock type seen in many of the xenoliths. It is usually medium grained, ophitic textured rock, but fine grained, aphyric, and plagioclase or plagioclase-pyroxene porphyritic varieties are also present. Locally the dikes are multiple with diabase chilled against diabase. The pendants and xenoliths are intruded and net-veined by a fine to medium grained, locally foliated granitoid which may form a separate early phase in the center of the complex. This rock has been recrystallized (thermally metamorphosed by later phases?) destroying obvious record of the composition, grain size and foliation in many places. The gabbros are commonly foliated whereas the diabases and volcanics show little effect of the deformation or thermal metamorphism. The sediments are hornfelses and were folded prior to the thermal event which largely healed the cleavage.

The above rocks are intruded by the major granitoid phases; a medium grained, hornblende granodiorite and a fine grained pink alaskite granite. The age relationship between these is not known. The hornblende granodiorite is metamorphosed, with chloritization of the ferromagnesian minerals and widespread saussuritization of feldspar. Of the accidental xenoliths, diabase and volcanics are abundant in the granodiorite but small, cognate(?) diorite and quartz diorite xenoliths are also common. The fine grained granite occurs along the western margin of the complex. In its northernmost part, it is free of xenoliths but everywhere north and northwest of Grand Le Pierre it contains abundant diabase inclusions.

Descriptions of the petrography and geochemistry of the Cross Hills Granite-Diorite Complex will be found in O'Brien *et al.* (in press).

GEOLOGY OF THE NORTH WEST BROOK COMPLEX AND EASTERN MEELPAEG COMPLEX

Definition and Extent

The term North West Brook Complex is proposed for a variety of strongly foliated granitoid rocks and associated metasedimentary rocks found in the southwest of the map area. This complex continues to the southwest into map areas 1M/11, 1M/12, 1M/13, where relationships have been mapped in greater detail by Williams (1971), Colman-Sadd (1976), and Colman-Sadd *et al.* (1979).

The complex is also known by a variety of names; White (1939) simply considered the rocks as "orthogneiss and paragneiss;" Jewell (1939) introduced the term "Garrison Hills Granite;" Widmer (1950) used the term "Garrison Hills Gneissic Granite;" Anderson (1965) termed the rocks "granite gneiss," Williams (1971) used the term "Garrison Hills Gneiss," Colman-Sadd (1976) described the rocks as "garnetiferous leucocratic granite and related rocks" but declined proposing a new name; Colman-Sadd *et al.*, (1979) described the corresponding rocks on the adjacent map area to the south as "equigranular, locally garnetiferous, muscovite or biotite granite."

The North West Brook Complex is named after the river known as North West Brook which is located about 4 km east of the Bay du Nord River and runs into East Bay. All lithologies included in the North West Brook Complex can be found in the vicinity of this river, although some are more extensively developed in other places.

The term Eastern Meelpaeg Complex is proposed for a variety of strongly foliated granitoid rocks with associated metasediments which outcrop in the northern part of the map area, around the eastern half and to the east of Eastern Meelpaeg Lake. The area underlain by the complex was included within the Ackley Granite by Jenness (1963). The complex is poorly exposed but clearly forms a large protrusion into the Ackley Granite. The boundaries of the unit are poorly defined and metasediments of the Gander Group dominate in the eastern part of the complex. The contact between the complex and the Gander Group is probably gradational. The occurrence of a deformed granitoid terrain was first noted by Whalen (1976) who examined samples collected by Strong *et al.* (1974).

The North West Brook and Eastern Meelpaeg Complexes are considered to be equivalent. They contain identical lithologies and show similar intrusive and structural histories.

Lithologies and Contact Relationships

Three main granitoid lithologies comprise the bulk of the North West Brook Complex and Eastern Meelpaeg Complex. These are shown on the map as Units 5, 6 and 7. Unit 5 is a medium to coarse grained, K-feldspar porphyritic, biotite tonalite, granodiorite or granite with a well developed cataclastic or regional tectonic fabric. The unit underlies most of the northern area of the North West Brook Complex but also occurs throughout the remainder of the complex as xenoliths and screens within Unit 6. Unit 5 is scattered throughout the Eastern Meelpaeg Complex. The nature of the survey did not permit mapping of exact contact relationships. Mapping was further hindered by lack of outcrop in the Koskaecodde Lake - Red Cliff Pond area.

Unit 6 consists of medium grained, equigranular to porphyritic, biotite ± muscovite ± garnet granodiorite to granite with a well developed tectonic fabric. This unit is equivalent to the "garnetiferous leucocratic granite" of Colman-Sadd (1976) and "equigranular locally garnetiferous, muscovite or biotite granite" of Colman-Sadd *et al.* (1979). Dikes of Unit 6 cut Unit 5 in many areas.

Unit 7 consists of medium grained, equigranular to pegmatitic, muscovite ± garnet ± tourmaline leucocratic granite with a weak to strong tectonic fabric. Dikes of this leucocratic granite are common throughout Unit 6 but are rare in Unit 5.

The various relationships displayed within the North West Brook Complex and Eastern Meelapeg Complex indicate that Unit 5 is the oldest; Unit 6 cuts Unit 5; and Unit 7 is the youngest component as both Units 5 and 6 are cut by Unit 7.

Included within the North Brook Complex are numerous outcrops of metasediment of undetermined extent. The metasediments consist of strongly schistose, polydeformed psammitic and semipelitic muscovite - biotite ± garnet ± sillimanite schist. The metasediments have been totally recrystallized and primary structures have been obliterated. According to Colman-Sadd (1976) "the gneissic foliation is crosscut by diorite and garnetiferous leucocratic granite and transposed by deformations affecting the Ordovician Baie d'Espoir Group. The gneisses are definitely pre-Ordovician and may well be Precambrian." Colman-Sadd (1976) shows several small areas of metasediment which occur as elongate screens within the foliated equigranular granite to the southwest of the map area and a similar distribution is envisioned for the North West Brook and Eastern Meelpaeg Complexes. Colman-Sadd (1976) considered the metasediments which occur as sheets within the foliated equigranular granite to be older than the Middle Ordovician Baie d'Espoir Group and possibly Precambrian.

Metamorphism and Structure of the Metasediments

The metasediments have been polydeformed and metamorphosed with early schistosities folded and transposed by later fabrics. The main deformation of the metasediments preceded emplacement of the granitoids since dikes of the main granitoid units cut across the main fabrics of the metasediment and the granite has subsequently been deformed with the metasediments, in a distinctly different orientation. The grade of metamorphism of the metasediments is upper greenschist to lower amphibolite facies with local development of sillimanite associated with muscovite, biotite and garnet forming the main schistosity. More commonly, however, the metasediments are muscovite-biotite psammitic schists with flattened and recrystallized quartz crystals defining the main fabric.

The relationship between the metasediments of the Baie d'Espoir Group to the northwest of the North West Brook Complex and the metasediments within the complex is not clarified by the few observations made during sample collection. There is an apparent increase in metamorphic grade to the southeast, however, there appears to be no greater history of structural events. The location of leucocratic foliated granitoids within high grade metamorphic terranes along the Gander Zone has been shown to be a function of the higher grade of metamorphism and not the greater age of the metasediments by Currie and Pajari (1977), who worked on equivalent rocks to the northeast of the Ackley Granite, in the Musgrave Harbour area.

Petrography of the granitoids from the Eastern Meelpaeg and North West Brook Complexes

Unit 5: Unit 5 in both complexes is identical and consists of a dark grey to buff colored, highly porphyritic, biotite-rich granodiorite and granite. The most prominent feature of the rock is the high proportion of 1 to 3 cm long perthite porphyroclasts set in a strongly aligned matrix of quartz, biotite and plagioclase.

The essential minerals are quartz, microcline or orthoclase perthite, plagioclase and biotite (Table 2). Hornblende is present in a few samples. Accessory minerals include sphene, magnetite, apatite, zircon, and rarely allanite. Alteration products include chlorite after biotite, sericite after biotite and feldspar, epidote after biotite and plagioclase, and hematite after magnetite and pyrite.

The potassium feldspar is microcline or orthoclase perthite and occurs mainly as large phenocrysts. There is little potassium feldspar in the groundmass. This is reflected in the modal analyses

TABLE 2: MODAL ANALYSES OF UNIT 5 IN THE NORTH WEST BROOK COMPLEX AND EASTERN MEELPAEG COMPLEX

a. NORTH WEST BROOK COMPLEX

SAMPLE	275	280	592	621	631	657	659	704
Quartz %	21.3	21.2	33.1	4.4	18.5	12.9	17.8	17.2
K-feldspar	18.6	17.3	2.8	51.7	27.1	32.1	6.8	13.9
Plagioclase	30.8	27.8	31.6	25.9	34.8	34.7	55.4	48.7
Biotite	23.2	29.2	30.3	17.9	16.5	17.9	18.8	19.2
Hornblende	Tr*	1.5	1.5	-	1.0	Tr	-	Tr
Opaques	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr
Sphene	1.2	-	1.5	Tr	1.0	0.8	0.7	Tr
Zircon	Tr**	Tr	Tr	Tr	Tr	Tr	Tr	Tr
Apatite	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr
Epidote	4.6	2.4	-	-	1.0	1.3	-	-
Allanite	-	Tr	-	-	-	-	-	-
Tourmaline	-	-	Tr	-	-	-	-	-
Sericite	Tr	Tr	1.5	Tr	Tr	Tr	Tr	Tr

b. EASTERN MEELPAEG COMPLEX

SAMPLE	106	107	157	158
Quartz %	17.7	10.2	26.3	24.8
K-feldspar	25.7	17.7	13.6	2.6
Plagioclase	38.4	44.9	51.3	42.5
Biotite	15.2	22.7	6.8	25.9
Hornblende	-	1.7	-	-
Opaques	Tr	Tr	Tr	Tr
Sphene	-	0.9	-	-
Zircon	Tr	Tr	Tr	Tr
Apatite	Tr	Tr	Tr	Tr
Epidote	Tr	1.4	-	1.1
Allanite	-	-	-	-
Sericite	2.7	Tr	1.7	1.8

Note for all tables of modal analyses.

* - Not seen in thin section.

** - Tr less than 0.5% of mode if present in thin section but not counted.

where the thin section does not include any perthite phenocrysts. In a few sections granophyre forms mantles around the perthite phencrysts.

Plagioclase occurs as small euhedral phenocrysts and as anhedral crystals in the groundmass. The phenocrysts are zoned from andesine to oligoclase and rarely have mantles of albite. Zonal alteration to sericite is common, and in a few samples epidote veins and patches occur in the plagioclase. Quartz occurs as anhedral crystals in most sections. In the strongly recrystallized granitoids, quartz forms elongate polygonal aggregates.

Biotite is abundant and occurs in parallel layers of dark brown to pale yellow sheaths up to 2 cm in length and 2 to 5 mm wide. Biotite and flattened, recrystallized quartz define the tectonic fabric in the rocks.

Hornblende, found in a few thin sections, is generally associated with biotite. The hornblende generally shows green to yellow pleochroism and is partly altered to chlorite. Sphene is conspicuous in a few hand specimens and forms crystals up to 5 mm in length.

The modes of selected samples are given in Table 2 and the proportions of quartz:plagioclase:alkali feldspar are given in Figure 3. The coarse grained, porphyritic texture of the rocks prevents accurate determinations of the porportions of the various minerals from one thin section. The distribution of ratios indicates that the granitoids are mainly granodiorite.

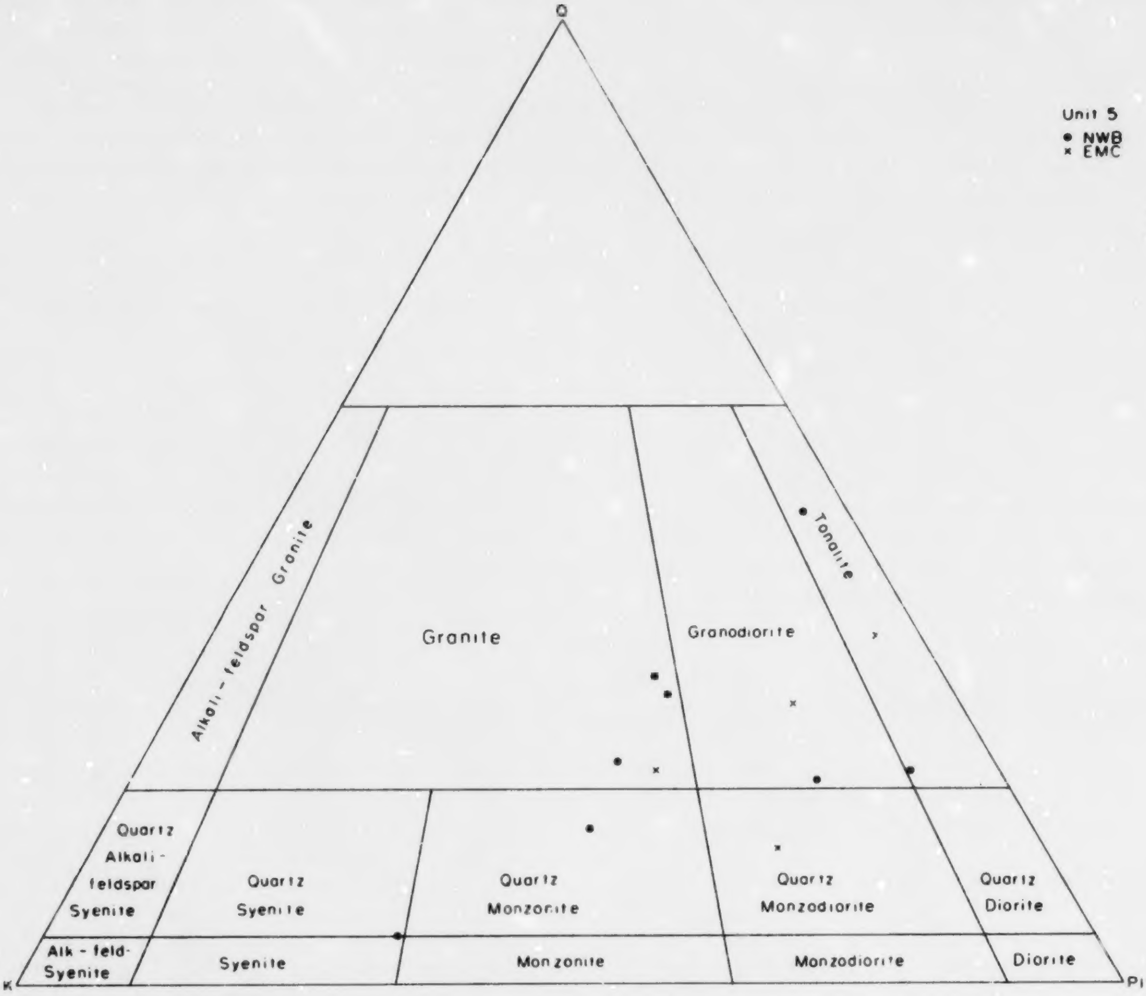
Unit 6: Unit 6 in both complexes is similar and varies from weakly foliated to strongly banded, biotite ± muscovite granodiorite or granite. The unit is characteristically a medium grained rock which is locally porphyritic with 5 to 10 mm phenocrysts of plagioclase and/or orthoclase perthite, with the fabric defined by aligned mica. The porportion of muscovite is highly variable and only rarely is garnet found with biotite-bearing granite. Granites lacking biotite but containing muscovite ± garnet ± tourmaline are by definition included in Unit 7. The essential mineralogy is quartz, orthoclase and/or microcline which is commonly perthitic, plagioclase, biotite, and usually muscovite. Accessory minerals may include magnetite, zircon, apatite, and very rarely garnet.

Alteration products include chlorite and sericite after biotite and feldspar, epidote after biotite and plagioclase, and hematite after magnetite.

Quartz occurs as anhedral aggregates, commonly with sutured grain boundaries, as isolated anhedral crystals, and as polygonized layers in the strongly banded and recrystallized granites in the Eastern Meelpaeg Complex.

The potassium feldspar is orthoclase or microcline and is commonly perthitic. Inclusions of plagioclase and/or biotite are common in the perthite phenocrysts.

Plagioclase occurs both as twinned and untwinned crystals and is usually slightly sericitized. Normal or oscillatory zoning occurs in a few crystals. Alteration commonly forms concentric zones in phenocrysts. In the Eastern Meelpaeg Complex some samples of Unit 6 show hematization of plagioclase. This is commonly accompanied by complete alteration of biotite to chlorite and is possibly caused by contact metamorphism by the adjacent Ackley Granite. Biotite is commonly well aligned and shows variable alteration to chlorite. Inclusions of zircon are common in biotite. Muscovite occurs as small flakes, usually less than 2 mm in length, and with biotite, defines the tectonic fabric. Secondary sericite also occurs as long flakes up to 2 mm, but is usually associated with altered plagioclase or biotite. Garnet was found in only one sample of biotite-bearing granite and forms 0.5 mm euhedral fractured crystals.



re 3: Modal proportions of Q:Pl:K (quartz:plagioclase:K-feldspar including perthite) for Unit 5 of the North West Brook (NWB) and Eastern Meelpaeg (EMC) Complexes with classification of granitoids from Streckeisen (1976).

Modal proportions of selected samples from Unit 6 are given in Table 3. The ratio of quartz:plagioclase: potassium feldspar shows that the dominant rock type is granite (Figure 4).

Unit 7: Unit 7 mainly consists of a leucocratic, medium grained, equigranular, variably deformed granite, characterized by the presence of muscovite, absence of biotite, and commonly containing garnet and tourmaline. This rock type commonly grades into very coarse pegmatite. The most common form of occurrence of the unit is as dikes, which cut the other members of the complexes. In a few places, Units 5, 6, or 3 occur as screens within Unit 7. The unit may form small plugs or thick sheets in a few areas, where all outcrops consist of this rock type. However, the area underlain by this rock type would be less than about 1 km^2 at any single locality.

The essential mineralogy of the unit is quartz, orthoclase or microcline perthite, albitic plagioclase, and muscovite. Garnet commonly is a prominent accessory. Locally, tourmaline forms large 1-5 cm rosettes with abundant inclusions of quartz and a few feldspar crystals. Zircon and opaque minerals are rare. Secondary sericite and epidote occur in a few samples. Modal proportions are given in Table 4, and quartz:plagioclase:alkali feldspar proportions are shown in Figure 5.

Quartz occurs as recrystallized, weakly strained, polygonized aggregates. Plagioclase forms phenocrysts in a few samples. More commonly it is restricted to the groundmass. A few crystals contain myrmekitic intergrowths with quartz. Zoning is rare. Slight alteration to sericite is common.

Potassium feldspar occurs as orthoclase, or in only a few samples as microcline and is only rarely perthitic. The proportion of albite varies from about 2% to nearly 50% and some may be considered antiperthite with the orthoclase forming numerous blotches in an albitic plagioclase.

Muscovite forms 1 to 3 mm flakes which are aligned and deformed and define the fabric. Garnet has two forms of occurrence. In a few samples, garnet forms small euhedral crystals up to about 1 mm across which are commonly fractured. In other samples, the garnets are up to 3 mm across and contain abundant inclusions of quartz and feldspar to give a poikilitic texture.

The rocks are variably deformed and recrystallized. A few samples show strong mylonitic fabrics with flattened quartz and small augen of feldspar. More commonly, however, the rocks show a weak tectonic fabric. The unit has been totally recrystallized. This is shown by the polygonal aggregates of quartz which are virtually strain-free.

Diabase Dike: A single diabase dike was found which cuts Unit 5. It is about 1 m wide, massive, and fine grained. The trend is 160° which is sub-parallel to prominent southeast trending valleys in the Bay du Nord River-North West Brook area.

In thin section, the dike is fine grained, and equigranular, with prominent 1-2 mm laths of andesine, subhedral augite, and abundant magnetite. There is slight alteration of the augite to chlorite, and slight sericitization of plagioclase. The dike is less altered than the granite host rock.

Deformation of the Eastern Meelpaeg and North West Brook Complexes

Virtually all rocks within the complexes show some sign of deformation. Only a few aplite dikes from the Ackley Granite which intrude the complexes and a single fine grained diabase dike are undeformed.

The deformation varies from a weak alignment of mica to intense mylonitiza-

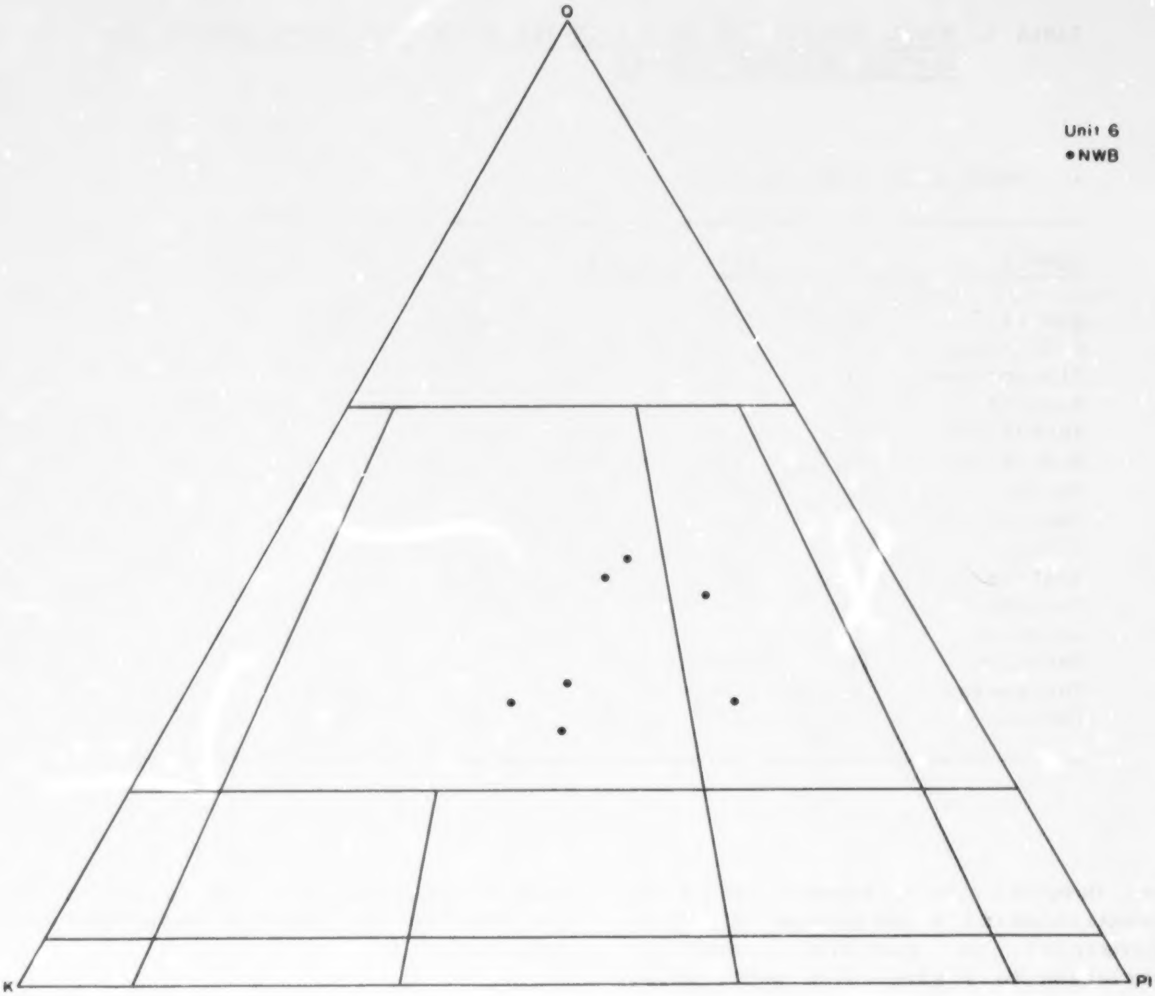
TABLE 3: MODAL ANALYSES OF UNIT 6 IN THE NORTH WEST BROOK COMPLEX AND EASTERN MEELPAEG COMPLEX

a. NORTH WEST BROOK COMPLEX

SAMPLE	221	243	297	479	632	729
Quartz %	36.8	28.7	23.2	38.6	35.3	26.1
K-feldspar	14.4	20.2	33.5	20.1	21.9	37.4
Plagioclase	34.0	49.5	32.4	29.2	26.4	27.2
Biotite	11.1	1.3	6.6	0.9	2.4	5.9
Hornblende	-	-	-	-	-	-
Muscovite	-	Tr	0.5	11.1	14.1	3.4
Opaques	0.9	Tr	0.6	Tr	Tr	Tr
Sphene	-	-	-	-	-	-
Zircon	Tr	-	Tr	Tr	Tr	Tr
Apatite	Tr	-	Tr	Tr	Tr	Tr
Epidote	2.7	Tr	2.6	Tr	-	-
Allanite	-	-	-	-	-	-
Sericite	Tr	Tr	0.5	Tr	Tr	Tr
Tourmaline	-	-	-	-	-	-
Garnet	-	-	-	Tr	-	-

b. EASTERN MEELPAEG COMPLEX

SAMPLE	102	104	141
Quartz %	40.7	43.2	43.2
K-feldspar	19.4	27.5	30.5
Plagioclase	30.4	22.3	19.6
Biotite	7.4	3.7	6.1
Hornblende	-	-	-
Muscovite	1.7	3.3	0.6
Opaques	0.5	Tr	Tr
Sphene	-	-	-
Zircon	Tr	Tr	Tr
Apatite	Tr	Tr	Tr
Epidote	Tr	-	-
Allanite	-	-	-
Sericite	Tr	Tr	Tr
Tourmaline	-	-	-
Garnet	-	-	-



igure 4: Modal proportions of Q:K:Pl (quartz:K-feldspar:plagioclase) for Unit 6 of the North West Brook (NWB) and Eastern Meelpae (EMC) Complexes. Granitoid fields as in Figure 3.

TABLE 4: MODAL ANALYSES OF UNIT 7 IN THE NORTH WEST BROOK COMPLEX AND EASTERN MEELPAEG COMPLEX

a. NORTH WEST BROOK COMPLEX						b. EASTERN MEELPAEG COMPLEX
SAMPLE	242	247	459	460	591	105
Quartz %	37.1	39.5	42.3	41.1	48.0	34.5
K-feldspar	18.0	1.0	26.9	14.3	9.9	27.4
Plagioclase	34.1	46.4	27.7	37.8	26.0	24.4
Biotite	Tr	-	-	-	-	-
Hornblende	-	-	-	-	-	-
Muscovite	10.7	12.1	2.9	6.9	1.7	9.5
Opaques	-	Tr	-	-	-	-
Sphene	-	-	-	-	-	-
Zircon	-	-	-	-	-	-
Apatite	Tr	Tr	Tr	Tr	-	Tr
Epidote	-	-	-	-	-	-
Allanite	-	-	-	-	-	-
Sericite	Tr	Tr	-	Tr	Tr	Tr
Tourmaline	-	-	-	-	14.3	-
Garnet	-	-	Tr	Tr	Tr	4.2

tion. However, there appears to be no concentration of a particular style of deformation in certain areas or restriction to a particular unit. This, however, may be due to the sampling method which may permit selection of only part of a mylonite zone.

Within the North West Brook Complex, only one tectonic fabric was usually found in the granitoid rocks. The trend of the fabric is northeasterly in the southern part of the complex and gradually changes towards east in the northeastern part of the complex. This gradual change in direction and the co-planar trend of mylonitic and non-mylonitic fabrics suggests that the two fabrics are synchronous. Within an outcrop, it is possible to find co-planar mylonitic and non-mylonitic fabrics, *e.g.* a granite dike may be weakly cleaved and cut a mylonitic granite but the fabrics have the same orientation.

There is no apparent increase in intensity of mylonitization towards the Hermitage Bay fault. There is, however, minor brecciation of the granitoids on both sides of the fault. This indicates that the mylonitic deformation of the granitoids is not related to fault movement.

Within the Eastern Meelpaeg Complex, deformation of the granitoid units is also of variable intensity, ranging from weak alignment of mica to strongly foliated granitoids. The strongly foliated granites are intimately associated with the upper greenschist facies metasediments. The metasediments are polydeformed with folded schistos-

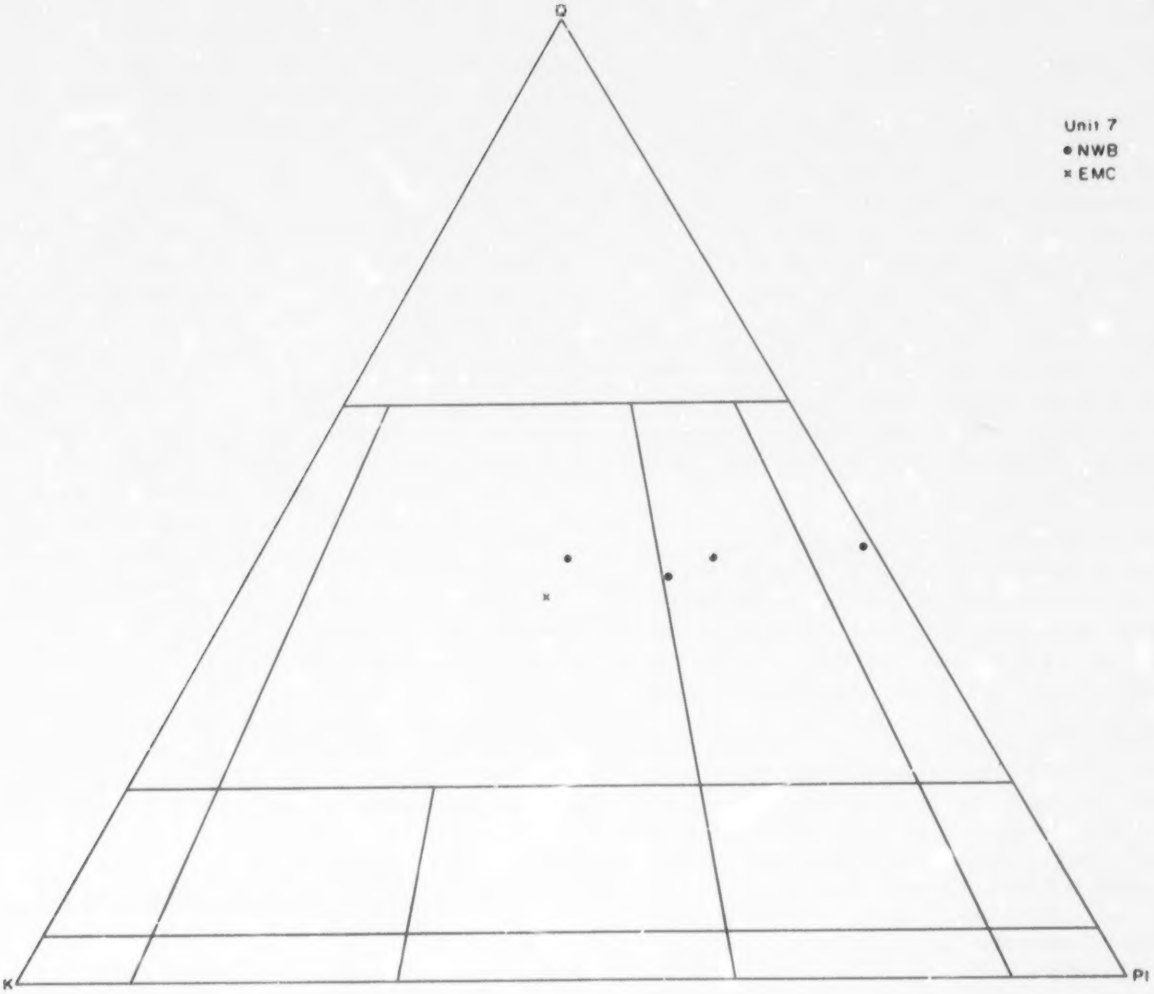


Figure 5: ***Modal proportions of Q:K:Pl (quartz:K-feldspar:plagioclase) for Unit 7 of the North West Brook (NWB) and Eastern Meelpa*** ***(EMC) Complexes. Granitoid fields as in Figure 3.***

ities, but the granites contain a single fabric. This again suggests that the metasediments have an earlier phase of deformation than the granitoids, as noted by Colman-Sadd (1976).

GEOLOGY OF THE ACKLEY GRANITE (UNITS 9-15)

Subdivisions of the Ackley Granite

The Ackley Granite has been divided into seven units (Units 9-15) based on mainly on textural, grain size, or mineralogical differences. Some of the divisions are based on thin section analysis, *e.g.* presence of microcline or orthoclase phenocrysts, and are, therefore, not obvious in the field. No contacts were found among the various subdivisions of the Ackley Granite. It is possible that some contacts are gradational and contacts between similarly textured intrusions may have been missed.

Aeromagnetic maps suggest that the Ackley Granite is not a single body. Most of the anomalies can be "explained" by the presence of roof pendants, or contacts with the older foliated plutonic units in areas previously shown as underlain by the Ackley Granite. However, in several cases, pre-Ackley Granite rocks are absent and therefore cannot be used to explain the anomaly. There are "basins" of low aeromagnetic relief, *e.g.* south of Kepenkeck Lake, and some strong linear anomalies, *e.g.* east of Jubilee Lake. These may indicate separate intrusions or contacts respectively.

The relative ages of the various subdivisions are not certain. The various age determinations (see Table 1) show a conflict between ^{40}Ar/^{39}Ar and K-Ar dates for the same unit. Dallmeyer (Newfoundland Department of Mines and Energy, 1980) reports an age of 355±10 Ma and Leech *et al.* (1963) report an age of 392±30 Ma. The date given by Bell *et al.* (1977) is difficult to assess as it contains samples from four of the units defined in this report. However, the low error on the isochron possibly indicates that the various units have a similar age.

Modal Analyses of the Ackley Granite

Thin sections have been point counted to determine the modal composition of the various units of Ackley Granite. The coarse grain size of most of the Ackley Granite does not permit precise mineral proportions to be determined. One thin section is available for each sample, and therefore, it was possible to omit a major crystal phase such as the microcline phenocrysts. Ideally, a large slab of granite, stained for K-feldspar, would have been better than a thin section. However, the modal proportions of quartz, alkali feldspar and plagioclase obtained from thin sections generally agree with the visual estimates of the ratio of the three minerals obtained from hand specimens. That is, rocks which were classified as granite or granodiorite from hand specimen would also be classified as such when the modal proportions were plotted on the plutonic rocks classification of Streckeisen (1976).

Modal analyses and plots of the quartz:alkali feldspar:plagioclase ratio are given with the description of each unit of the Ackley Granite.

Unit 9 - Coarse Grained, Massive, Porphyritic, Biotite±Hornblende Granodiorite

Definition and Extent

Unit 9 forms a westerly trending protrusion on the west side of the Ackley Granite, south of Jubilee Lake. Unit 9 consists mainly of coarse grained, massive, microcline porphyritic, biotite granite and granodiorite with minor, medium grained, biotite granite (Figure 6). The unit is variably porphyritic and locally contains less than 5% phenocrysts. Thin section analysis shows the presence of accessory hornblende. Contacts between

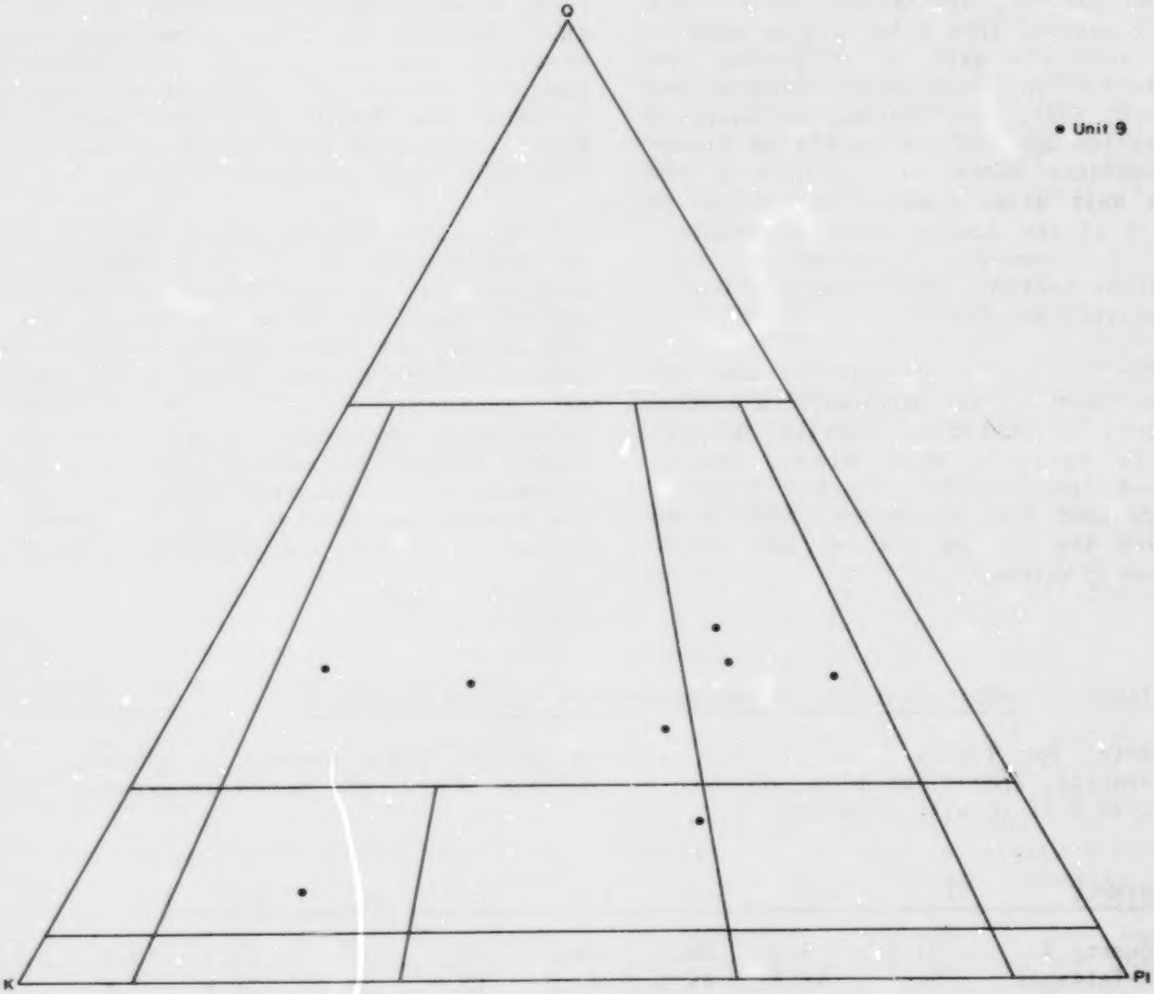


Figure 6: Modal proportions of Q:K:Pl (quartz:K-feldspar:plagioclase) for Unit 9 of the Ackley Granite. Granitoid fields as in Figure 3.

Unit 9 and the metasediments were not found. However, the contact with the metasediments and minor volcanic rocks in the Medonnegonix Lake to Jubilee Lake area is certainly intrusive. Aplite dikes cut the metasediments and, close to the contact, the metasediments have been converted into a 500 m wide zone of hard hornfels with local garnet and cordierite porphyroblasts (Swinden and Dickson, 1981). The eastern and southern boundaries are defined partly on linear aeromagnetic anomalies. Unit 5 of the North West Brook Complex is similar to Unit 9 of the Ackley Granite. However, Unit 5 commonly displays a well developed tectonic fabric whereas Unit 9 is entirely massive.

The contact with Unit 12 was not found. Unit 12 is dominantly a medium grained, porphyritic, biotite granite but is variable with minor, coarse grained, porphyritic, biotite granite. The contact has, therefore, been drawn between the medium grained and coarse grained granites.

Lithology

The essential mineralogy of Unit 9 is quartz, microcline perthite, plagioclase and biotite. Hornblende was found in a few samples commonly as 1 to 4 mm blades. Sphene was found in most thin sections as 1 to 3 mm euhedral crystals. Apatite, zircon, and opaques (mainly magnetite) are ubiquitous. Allanite was found in a few samples. Modal analyses of representative samples from Unit 9 are presented in Table 5.

Microcline occurs mainly as 1 to 4 mm euhedral crystals with variably developed string exsolution lamellae of albite. Small inclusions of quartz and plagioclase are common within the phenocrysts. Quartz occurs in the groundmass as anhedral crystals which are invariably strained. Plagioclase is partly altered to sericite and locally epidote. Commonly, only the margin of the plagioclase crystal is fresh. Normal zoning is common and is usually only

TABLE 5: MODAL ANALYSES OF REPRESENTATIVE SAMPLES OF UNIT 9

Note: For Tables 5 to 11. Most samples contain trace amounts of zircon, apatite, sphene, epidote, allanite and opaques. Where this amount is greater than 0.3% it will be noted.

SAMPLE	514	520	523	535	540	543	650	599
Quartz %	31.9	9.3	28.0	29.3	30.8	15.5	19.5	23.5
K-feldspar	54.4	66.5	39.1	17.3	15.9	28.0	21.4	7.8
Plagioclase	11.3	20.0	23.0	42.1	37.8	49.5	34.0	42.8
Biotite	2.5	3.7	9.9	11.1	12.9	5.5	25.2	19.9
Muscovite	-	-	-	-	-	-	-	-
Hornblende	-	-	-	-	-	0.5	-	1.2
Others	-	0.5*	-	-	1.0+	-	-	4.8**

* Epidote
+ Sphene
** Opaques 3.0%, Sphene 1.8%

slight. The plagioclase ranges in composition from oligoclase to andesine in the biotite-rich granodiorite. In the more leucocratic granites the plagioclase is oligoclase. Biotite is locally abundant and forms flakes and "books" up to 1 cm in diameter. The biotite is commonly partly altered to chlorite and magnetite.

Few pegmatites, aplites or quartz veins were found. However, near the southern contact, 2 km southwest of Medonnegonix Lake several small aplites and granitic pegmatites cut pink, coarse grained, porphyritic biotite granite in which the biotite is altered to chlorite. One 40 cm wide aplite contains muscovite and tourmaline and 1 to 2 mm flakes of molybdenite. The molybdenite concentration is less than 0.1%.

Unit 10 - Massive, Coarse Grained, Porphyritic, Biotite Granite

Definition and Extent

Unit 10 forms an irregularly shaped body at the northeast corner of the map area. Aerial photograph interpretation suggests that a part of the unit exposed near Mollyguajeck Lake is separated from the main part of Unit 10 by metasediments of the Gander Group and thus may form a cupola.

The dominant rock type in Unit 10 is massive, coarse grained, porphyritic biotite granite and granodiorite with 2 to 5 cm microcline perthite phenocrysts (Figure 7). The presence of microcline ± orthoclase phenocrysts rather than only orthoclase perthite phenocrysts forms the boundary between Unit 10 and Unit 11. Aerial photographs show a northeast-trending lineament which may be a fault and coincides with this boundary.

Contacts between Unit 10 and the surrounding units are not exposed. However, as the granite of Unit 10 is massive and is bounded on three sides by strongly foliated granites and metasediments, it almost certainly cuts the rocks of the Gander Group and the Eastern Meelpaeg Complex.

Lithology

The essential mineralogy of Unit 10 is quartz, microcline perthite, plagioclase, and biotite. Hornblende was found in thin sections of a few samples but was not obvious in hand specimen. Accessory minerals may include sphene, apatite, zircon, opaques (mainly magnetite), and rarely allanite (see Table 6).

Microcline perthite occurs mainly as phenocrysts with a smaller porportion in the groundmass. Inclusions of plagioclase are common in the phenocrysts. String perthite exsolution lamellae of albite in microcline are abundant.

Plagioclase is commonly oligoclase (approximately An_{25}) but also shows some normal and oscillatory zoning. Alteration to sericite varies from a few tiny flakes to complete alteration. Epidote is also present in a few samples.

Biotite forms a sizable proportion of many samples (see Table 6) and occurs as books up to 1 cm in diameter and 2 to 3 mm in thickness. Alteration to chlorite is variable and, in some samples, the biotite is totally altered. Inclusions of zircon and magnetite are common. Sphene occurs in a few samples as euhedral crystals. A few small granitic pegmatites, aplites and quartz veins were found in Unit 10, but no economic minerals were found.

Unit 11 - Massive, Porphyritic, Medium to Coarse Grained, Biotite ± Muscovite Granite

Definition and Extent

Unit 11 forms an elongate body at the northwest corner of the Ackley Granite. It is bounded to the west and

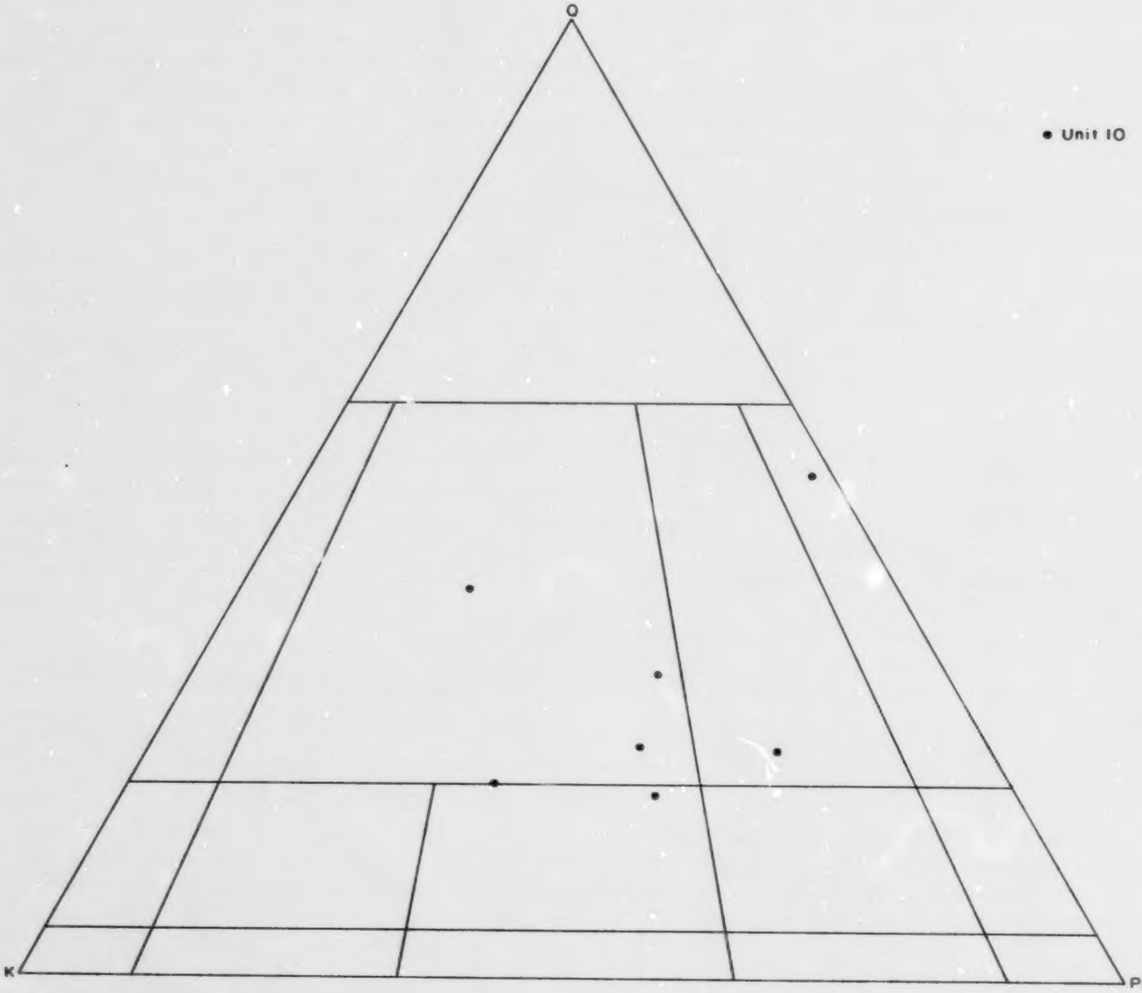


Figure 7: Modal proportions of Q:K:Pl (quartz:K-feldspar:plagioclase) for Unit 10 of the Ackley Granite. Granitoid fields as in Figure 3.

TABLE 6: MODAL ANALYSES OF REPRESENTATIVE SAMPLES OF UNIT 10

SAMPLE	56	61	65	78	85	92	138	99
Quartz %	40.1	28.2	20.9	18.8	23.9	15.6	19.8	41.0
K-feldspar	38.2	23.0	27.2	43.0	24.5	26.9	15.8	1.4
Plagioclase	20.4	37.1	40.0	30.5	37.1	39.4	47.0	35.4
Biotite	1.3	8.9	13.9	7.6	13.8	13.1	13.9	17.4
Muscovite	-	2.3	-	-	-	-	-	-
Hornblende	-	-	-	-	Tr	1.9	2.0	4.2
Others	-	0.5*	-	-	0.6*	3.2+	2.5++	0.7*

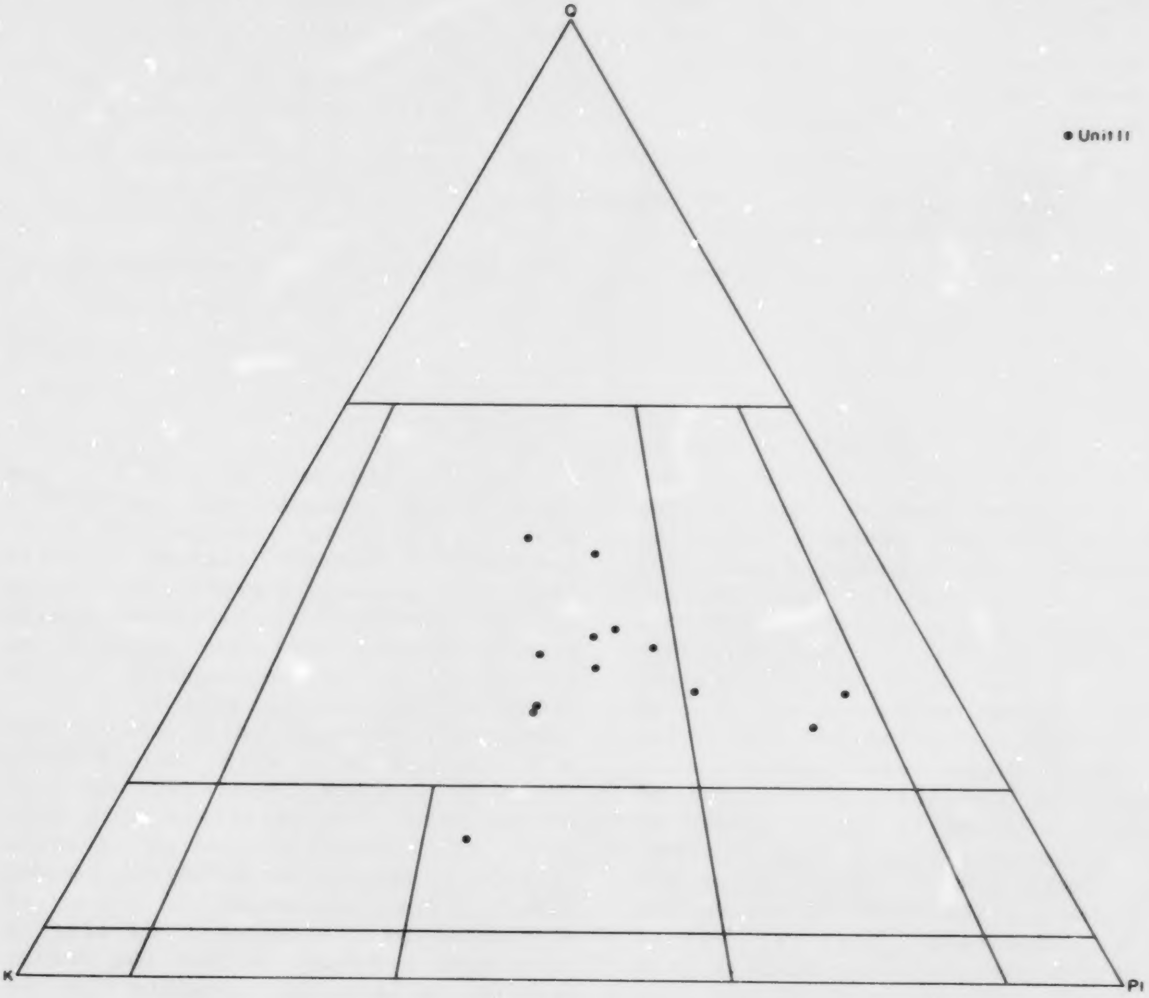
* Opaques
+ Epidote 1.3%, Sericite, 1.3%, Opaques 06.%
++ Sericite 0.5%, Opaques 1.0%

north by metasediments of the Gander Group, to the east by Unit 10 and the metasediments and granitoids of the Eastern Meelpaeg Complex, and to the south by Unit 12. Contacts with the surrounding rock are poorly exposed. The Gander Group has been contact metamorphosed by the Ackley Granite to a hard hornfels. The more pelitic units within 100 to 200 m of the contact contain abundant porphyroblasts of 1 cm long, stubby, retrogressed cordierite crystals. These are particularly abundant at the northeastern end of Kepenkeck Lake and to the northeast of Mount Sylvester (Swinden and Dickson, 1981). Small massive aplite veins and pegmatites cut the Gander Group and the Eastern Meelpaeg Complex. These intrusions are probably derived from Unit 11. A small isolated outcrop less than 50 m^2 in area occurs at the eastern end of Kepenkeck Lake and is virtually surrounded by contact metamorphosed, cordierite-rich pelites. Jenness (1963) has mapped this outcrop as an isolated plug of granite. This is most likely and the plug is probably a small offshoot from the main body of granite, which it may join at shallow depth. This would account for the extensive development of cordierite in this area.

Lithologies

Unit 11 has been divided into two subunits. The dominant rock type in Unit 11 is massive, coarse grained, porphyritic, biotite granite (subunit 11a) which apparently grades into medium grained, porphyritic, biotite-muscovite granite (subunit 11b) (see Figure 8 and Table 7). The biotite-muscovite granite underlies the central part of Unit 11 between the southern end of Jubilee Lake and the contact with the Eastern Meelpaeg Complex. A pronounced oval aeromagnetic low coincides with this area of muscovite-bearing granite (Figure 9; Geological Survey of Canada, 1968). The aeromagnetic low is surrounded by a pronounced increase in aeromagnetic relief within the Ackley Granite. It is clearly possible that the biotite-muscovite granite of subunit 11b represents a separate unit which intrudes the coarse grained, porphyritic granite of subunit 11a.

Muscovite occurs in subunit 11b as well formed crystals which are commonly visible in hand specimen (see Appendix II). The muscovite occurs as 2 to 4 mm flakes and is generally less abundant than biotite. In thin



8: Model proportions of Q:K:Pl (quartz:K-feldspar:plagioclase) for Unit 11 of the Ackley Granite. Granitoid fields as in Figure 3.

TABLE 7: MODAL ANALYSES OF REPRESENTATIVE SAMPLES OF UNIT 11

a. Subunit 11a

SAMPLE	73	76	84	182	345	501	528
Quartz %	29.0	24.4	28.7	28.8	42.6	25.9	42.9
K-feldspar	22.6	33.2	27.4	9.6	24.1	14.2	28.6
Plagioclase	44.5	28.1	31.7	57.5	29.0	57.4	21.7
Biotite	3.9	14.3	11.0	4.1	4.3	1.5	5.0
Muscovite	-	-	-	-	-	-	-
Hornblende	-	-	-	-	-	-	-
Others	-	-	1.2*	-	-	1.0**	1.8z

* Epidote 0.6, Sphene 0.6
** Opaques 0.5, Epidote 0.5
z Opaques 1.2, Sphene 0.6

b. Subunit 11b

SAMPLE	66	68	96	176	178	526
Quartz %	27.0	13.6	33.1	32.4	33.6	33.5
K-feldspar	37.7	48.0	24.8	23.2	35.2	27.9
Plagioclase	31.6	31.1	32.7	37.3	30.0	32.1
Biotite	2.8	4.9	7.0	5.6	0.6	5.6
Muscovite	0.5	2.5	1.9	0.7	0.6	0.5
Hornblende	-	-	-	-	-	-
Others	0.5++	-	0.6++	0.7++	-	0.5+

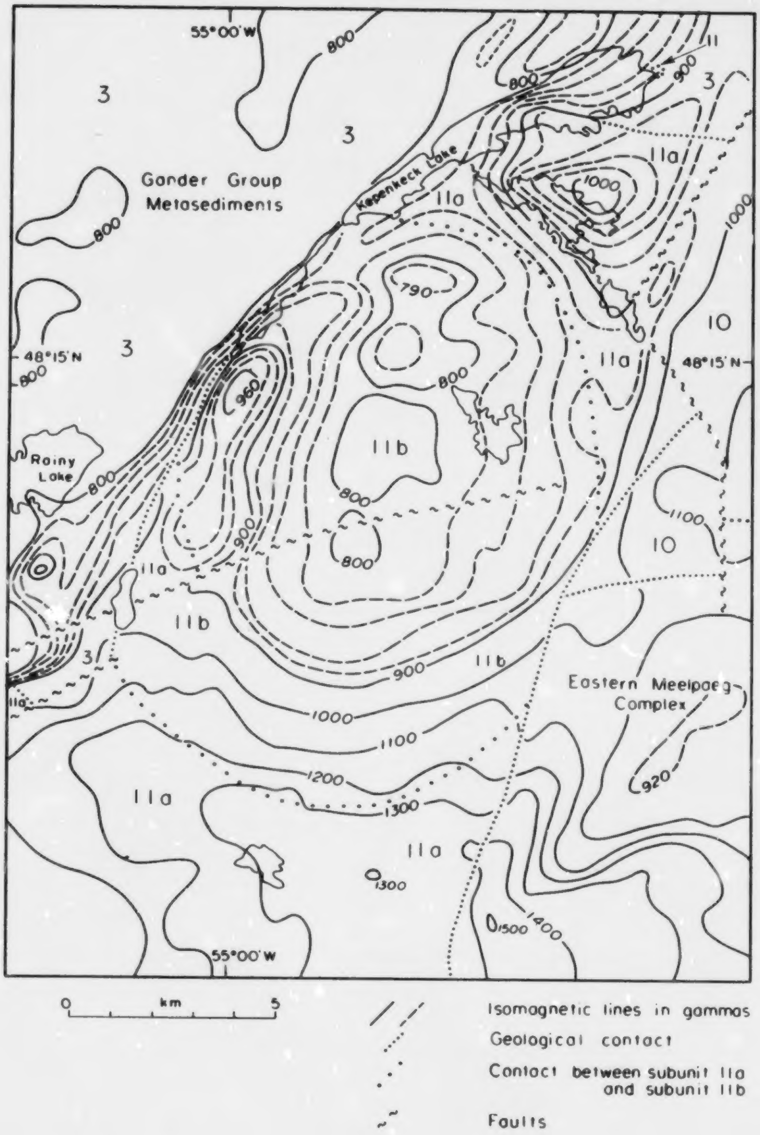
++ Opaques
+ Epidote

section, muscovite occurs as an interstitial phase of well formed 1 to 2 mm crystals. Sericite is also common in subunit 11a and has formed by alteration of plagioclase and biotite. Sericitic alteration of plagioclase is more common in subunit 11b than in subunit 11a.

There are, however, broad petrographic similarities between subunit 11b and subunit 11a. The granites are composed of quartz, orthoclase perthite, plagioclase, and biotite, in addition to muscovite in subunit 11b. Perthite and plagioclase phenocrysts commonly form rectangular crystals up to 4 cm in length. In a few cases, the plagioclase shows a strong oscillatory zoning with sharp compositional boundaries between layers. The plagioclase is variably altered to sericite and locally epidote. The perthite occurs mainly as phenocrysts with string exsolution lamellae. Quartz is anhedral and variably strained. Biotite generally is partly altered to chlorite, but locally is also altered to sericite and epidote, with small amounts of magnetite.

Accessory minerals may include magnetite, sphene, apatite, zircon, and rarely allanite.

Aplite dikes and granitic pegmatites are rare within Unit 11. At locality 59, 1 km southeast of Kepenkeck Lake, the rock type is porphyritic aplite. This


55°00'W
800
3
3
Gander Group
Metasediments
Kepenkeck Lake
11
900
3
11a
1000
1000
11a
790
10
48°15'N
3
48°15'N
11a
800
960
800
11b
Rainy
Lake
800
800
900
1100
800
10
11a
11b
3
900
11b
11a
Eastern Meelpaeg
Complex
1000
1100
920
1200
11a
1300
11a
1300
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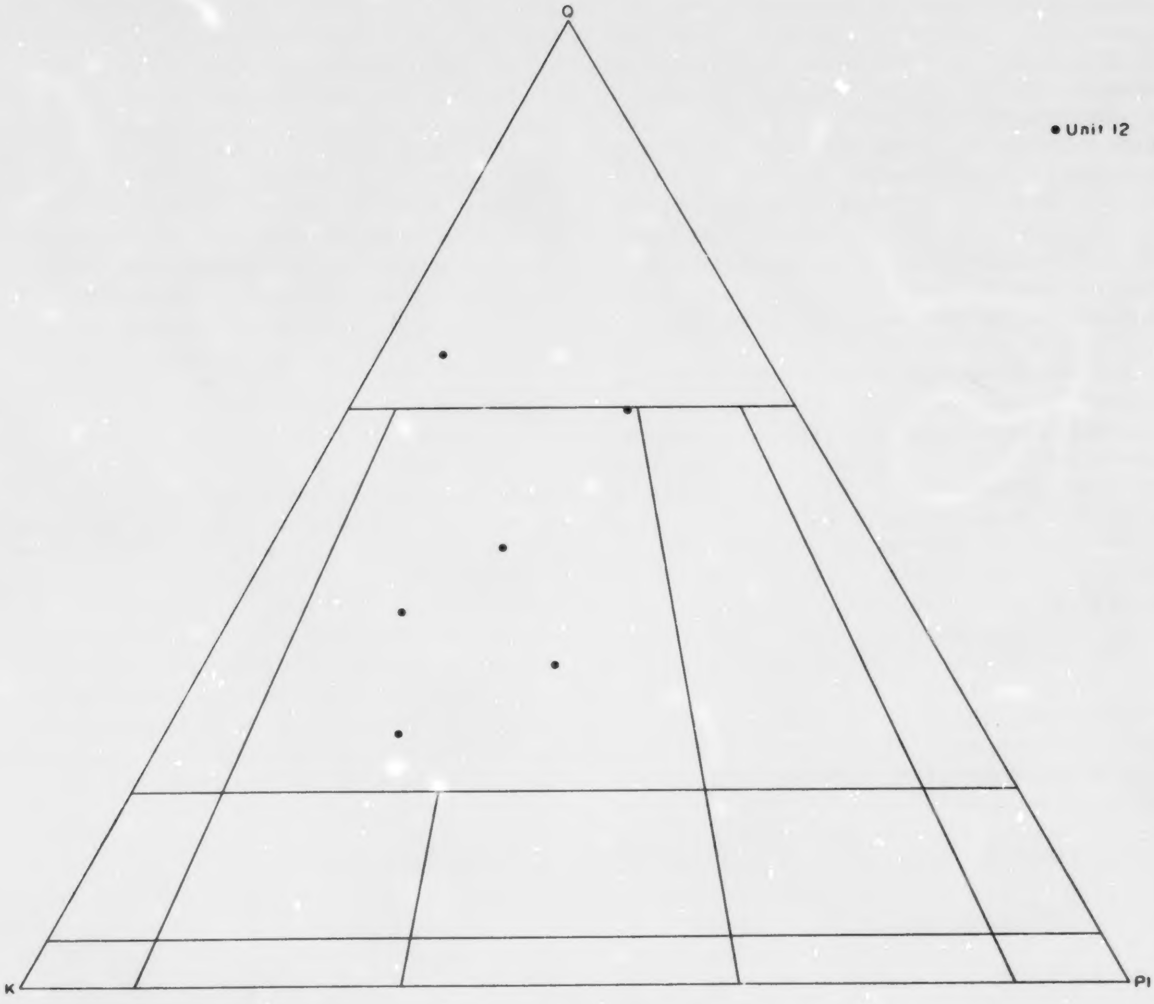
55°00'W
0
km
5
Isomagnetic lines in gammas
Geological contact
Contact between subunit 11a
and subunit 11b
Faults

Figure 9: ***Aeromagnetic anomaly map in the vicinity of subunit 11b of the Ackley Granite.***

may be a late stage dike or an offshoot from subunit 11b. At locality 54, on the north side of Kepenkeck Lake, the Gander Group metasediments are cut by a dike of garnet-muscovite granite close to the contact with Unit 11. No garnet-muscovite-bearing granitoids are known from any part of the Ackley Granite. The dike, therefore, may be related to the Eastern Meelpaeg Complex.

No mineralization has been found within Unit 11. Minor chalcopyrite-pyrite-pyrrhotite and galena mineralization occurs within the contact metamorphosed pelites of the Gander Group. The mineralization occurs in 10 cm long quartz veins which probably formed during contact metamorphism.



igure 10: Modal proportions of Q:K:Pl (quartz:K-feldspar:plagioclase) for Unit 12 of the Ackley Granite. Granitoid fields as in Figure 3.

Unit 12 - Massive, Medium to Coarse Grained, Porphyritic, Biotite Granite

Definition and Extent

Unit 12 consists mainly of gray, medium grained, porphyritic, biotite granite with minor, coarse grained, porphyritic, biotite granite (Figure 10). Dikes of the medium grained granite commonly cut the coarse grained granite. The nature of the contacts with the surrounding units are unknown. However, the common occurrence of the medium grained granite strongly suggests a distinct unit. The coarse grained granites could possibly be extensions of the surrounding units which have been injected by the medium grained granite.

The relationship between Units 9 and 11 and Unit 12 has already been discussed. The contact relationships between Unit 12 and Units 14 and 15 are uncertain. However, there is an apparent change in grain size towards the east and south from medium to coarse, which possibly indicates two separate intrusions.

One feature, which suggests that Unit 12 is older than some of the surrounding units, is that biotite locally occurs as fine grained, randomly orientated aggregates, which may have formed by recrystallization during contact metamorphism. In a few samples, quartz and plagioclase have recrystallized and form veinlets which cut feldspar crystals.

Geochemical evidence suggests a difference between Unit 12 and Units 14 and 15 (see Table 13). The mean SiO_2 content of Unit 12, for example, is lower although there is a slight overlap of SiO_2 values at the higher levels.

Aeromagnetic anomaly patterns indicate the general position of the contact between Unit 9 and Unit 12. A generally north-trending aeromagnetic high also corresponds with the eastern contact with Unit 16. However, the northern and southern contacts are not well defined by an aeromagnetic anomaly.

Lithology

The main rock type of Unit 12 is gray to locally pink, medium grained, porphyritic, massive, biotite granite. The phenocryst phases are orthoclase perthite and plagioclase which form 1 to 3 cm long, subhedral crystals, in a medium to locally fine grained, equigranular matrix of plagioclase, orthoclase perthite, quartz, and biotite (Table 8). Gray, coarse grained, porphyritic, biotite granite forms about 20% of the samples obtained from Unit 12.

TABLE 8: MODAL ANALYSES OF REPRESENTATIVE SAMPLES OF UNIT 12

SAMPLE	191	346	352	354	429	522
Quartz %	26.5	57.1	6.2	30.0	37.3	43.6
K-feldspar	52.4	14.3	44.2	31.4	44.0	31.8
Plagioclase	21.1	24.0	37.0	28.6	14.5	20.0
Biotite	Tr	4.5	10.1	9.3	4.2	4.5
Muscovite	-	-	-	-	-	-
Hornblende	-	-	-	-	-	-
Others	-	-	1.6*	0.7**	-	-

* Opaques 0.8, Sericite 0.8
** Opaques

Many of the samples from Unit 12 show the effects of low grade metamorphism and recrystallization. In one sample, from locality 352, the plagioclase has recrystallized to form polygonal albite aggregates. The rock is severely depleted in quartz and could be classified as a quartz monzonite. C.I.P.W. norm calculations for this sample give minor normative olivine (Colman-Sadd *et al*., 1981).

The plagioclase is commonly green. In thin section, the plagioclase is variably sericitized, and also occurs as inclusions in the perthite phenocrysts. Zoned crystals are common. Quartz mainly occurs as an interstitial phase and is only slightly strained. The perthite commonly is mantled by albite.

Accessory minerals include sphene, apatite, opaques and zircon. Some of the zircon crystals are strongly zoned.

A few aplite dikes cut the main phases of Unit 12. One of these (locality 430, 9 km southwest of Jubilee Lake) contains graphic intergrowths and large (3 cm x 4 mm) miarolitic cavities. This shows that the aplite was emplaced at a high structural level. Cavities were not found in any other part of Unit 12. This suggests several possibilities. The aplite is possibly unrelated to the granite of Unit 12 and has been derived from the highly miarolitic Unit 14 to the south, or the granite of Unit 12 may have attained saturation in water late in the crystallization of the granite magma. It is possible that some of the granite in this area should be included in Unit 14. However, differences in grain size and the higher proportion of accessory minerals, in Unit 12 in this area, suggest that the two units are unrelated.

No quartz veins were found in Unit 12.

Unit 13 - Coarse Grained, Porphyritic, Massive, Biotite Granite

Definition and Extent

Unit 13 consists dominantly of pink, coarse grained, porphyritic, massive, biotite granite with minor areas of massive, medium grained, equigranular biotite granite, which is locally miarolitic, and massive, fine grained, miarolitic, porphyritic, biotite aplite. The main areas of the finer grained granites are Old Woman Ridge and Sandy Harbour Ridge near the southeastern margin of the unit.

The most prominant feature of the unit is the abundance of coarse, subhedral phenocrysts of orthoclase perthite up to 5 cm in length and 4 cm in width which form up to 40% by volume of the rock. This abundance of coarse phenocrysts is the main criterion used to separate Unit 13 from Unit 14. However, local variations of the phenocryst population in both units can make distinction difficult.

Unit 13 also contains a higher proportion of, and generally coarser grained, biotite than Unit 14.

The contacts between Units 13, 14 and 15 of the Ackley Granite were not found. The contact area between Unit 13 and Unit 15 is very poorly exposed and the boundary is drawn based on the aeromagnetic anomaly pattern. To the northwest of Tolt Brook, Unit 15 corresponds with an aeromagnetic low and the boundary between Units 13 and 15 is taken as the southern boundary of this low.

The contact between Unit 13 and the Precambrian metasediments is well exposed along the Burin Peninsula highway near the southeast corner of the map area, and at various localities in the area of Precambrian roof pendants, particularly in the Dunn's Mountain area. The country rocks at the contact with the Ackley Granite are cut by granite dikes in only a few places. Generally the contact is sharp. On the Burin Peninsula highway, at the contact, a 1 m thick, coarse granite pegmatite dike cuts the metasediments. In the Dunn's Mountain area, medium-coarse grained, biotite granite dikes up to 2 m wide can be traced from the contact into the metasediments for up to 15 m (G.A.G. Nunn, personal communication, 1980). The metasediments in contact with the granite have been metamorphosed within an aureole less than 200 m wide, with the development of biotite, and locally muscovite, cordierite and andalusite porphyroblasts. Massive sandstones have been recrystallized to produce a hard hornfels, while recrystallization of laminated sandstones has produced a gneissic banding. The sandstones exposed at the contact on the Burin Peninsula highway, also contain isolated granitic veinlets which are probably the result of local anatexis. A basic dike, which cuts the metasediments at the contact, has been metamorphosed by the granite to an assemblage of albite, actinolite, biotite and magnetite.

In the Dunn's Mountain area, sandstone xenoliths contain alkali-feldspar porphyroblasts and have developed a gneissic fabric.

East of Whitehead Pond (locality 129), abundant cordierite porphyroblasts occur in the 10-30 cm thick sandstone beds of the Musgravetown Group. The nearest outcrop of granite is more than 8 km to the southwest. The corderite probably formed during contact metamorphism and, there, the granite contact is probably within 200 m of the sandstone.

Xenoliths are rare within Unit 13. Usually the xenoliths are the local country rock and are restricted to within 5 m of the contact. At locality 6, a 3 m long, stoped block of metasediment is included in the granite at the contact.

Highly resorbed, 2 to 5 cm long, ovoid xenoliths of biotite quartz diorite are scattered throughout Unit 13. However, they form a very small proportion of outcrop (<0.01%). The xenoliths are medium grained, equigranular, and massive, with a hypidiomorphic granular texture.

Lithologies

The dominant rock type of Unit 13 is pink, massive, coarse grained, porphyritic, biotite granite. The granite typically contains up to 20% tabular to ovoid orthoclase perthite phenocrysts, up to 4 cm in length, in a groundmass of quartz, perthite, plagioclase, and biotite, with sphene and allanite as locally prominent accessories. Modal analyses suggest that some of the unit should be classified as alkali-feldspar granite (see Table 9; Figure 11).

Aplite dikes occur throughout Unit 13. They vary in width up to 1 m and some, exceed 50 m in length. On Old Womans Ridge and Sandy Harbour Ridge, miarolitic aplite and microgranite dikes cut coarse grained granite and underlie areas up to 0.5 km^2. More commonly, the aplite occurs as discrete pods and lenses up to 10 m in diameter. At localities 33 and 34, the coarse grained granite is cut by abundant aplite dikes. At locality 34, the main rock type is medium grained, miarolitic granite which forms a small plug-like body about 0.5 km in diameter. Similarly, at locality 415 which is 3 km southeast of Pin Hill, the entire outcrop, which is about 100 m long, is composed of miarolitic, aplitic granite.

Thin sections of the granites show that the granite groundmass is mainly hypidiomorphic granular and locally granophyric. The microgranites and aplites are commonly granophyric.

TABLE 9: MODAL ANALYSES OF UNIT 13

SAMPLE	6	28	33	171	200	204	211	212+
Quartz %	37.2	6.8	8.6	29.6	36.4	49.1	26.6	31.2
K-feldspar	22.8	39.7	78.8	57.9	39.8	43.9	67.0	54.0
Plagioclase	34.5	51.4	7.4	12.5	23.0	6.4	1.6	8.1
Biotite	5.0	1.4	5.1	Tr	0.8	0.6	4.8	6.6
Muscovite	-	-	-	-	-	-	-	-
Hornblende	-	Tr	-	-	-	-	-	-
Others	0.6*	0.7**	-	-	-	-	-	-

SAMPLE	321+	359	361	364	377	380	381	385+
Quartz %	49.8	11.4	24.7	44.3	48.4	49.0	27.7	35.1
K-feldspar	44.3	67.5	45.1	46.7	39.1	44.0	66.2	54.0
Plagioclase	5.9	15.7	22.8	6.0	12.6	4.6	5.6	9.9
Biotite	Tr	5.42	6.2	3.0	Tr	2.5	0.5	1.0
Muscovite	-	-	-	-	-	-	-	-
Hornblende	-	-	-	-	-	-	-	-
Others	-	-	1.2***	-	-	-	-	-

SAMPLE	397	403	406	412	414	415+	417	421
Quartz %	43.2	48.7	37.3	36.1	29.8	48.4	29.2	36.3
K-feldspar	43.6	38.5	45.2	51.0	56.2	30.5	66.1	42.3
Plagioclase	9.0	12.7	15.2	8.7	5.8	15.8	1.3	12.8
Biotite	4.1	Tr	2.3	4.2	8.3	5.3	3.4	8.6
Muscovite	-	-	-	-	-	-	-	-
Hornblende	-	-	-	-	-	-	-	-
Others	-	-	-	-	-	-	-	-

SAMPLE	432	435	442	547	556+	558	565	579	741
Quartz%	49.3	19.8	20.5	31.5	32.1	39.2	28.5	20.2	12.9
K-feldspar	38.9	71.2	75.9	52.6	42.2	49.1	69.5	59.6	68.7
Plagioclase	10.9	6.8	3.6	11.7	24.6	8.2	0.5	13.5	5.5
Biotite	.9	2.3	Tr	4.2	1.1	3.4	1.5	6.7	1.5
Muscovite	-	-	-	-	-	-	-	-	-
Hornblende	-	-	-	-	-	-	-	-	-
Others	-	-	-	-	-	-	-	-	-

+ Aplite

* Magnetite

** Epidote

*** Opaques

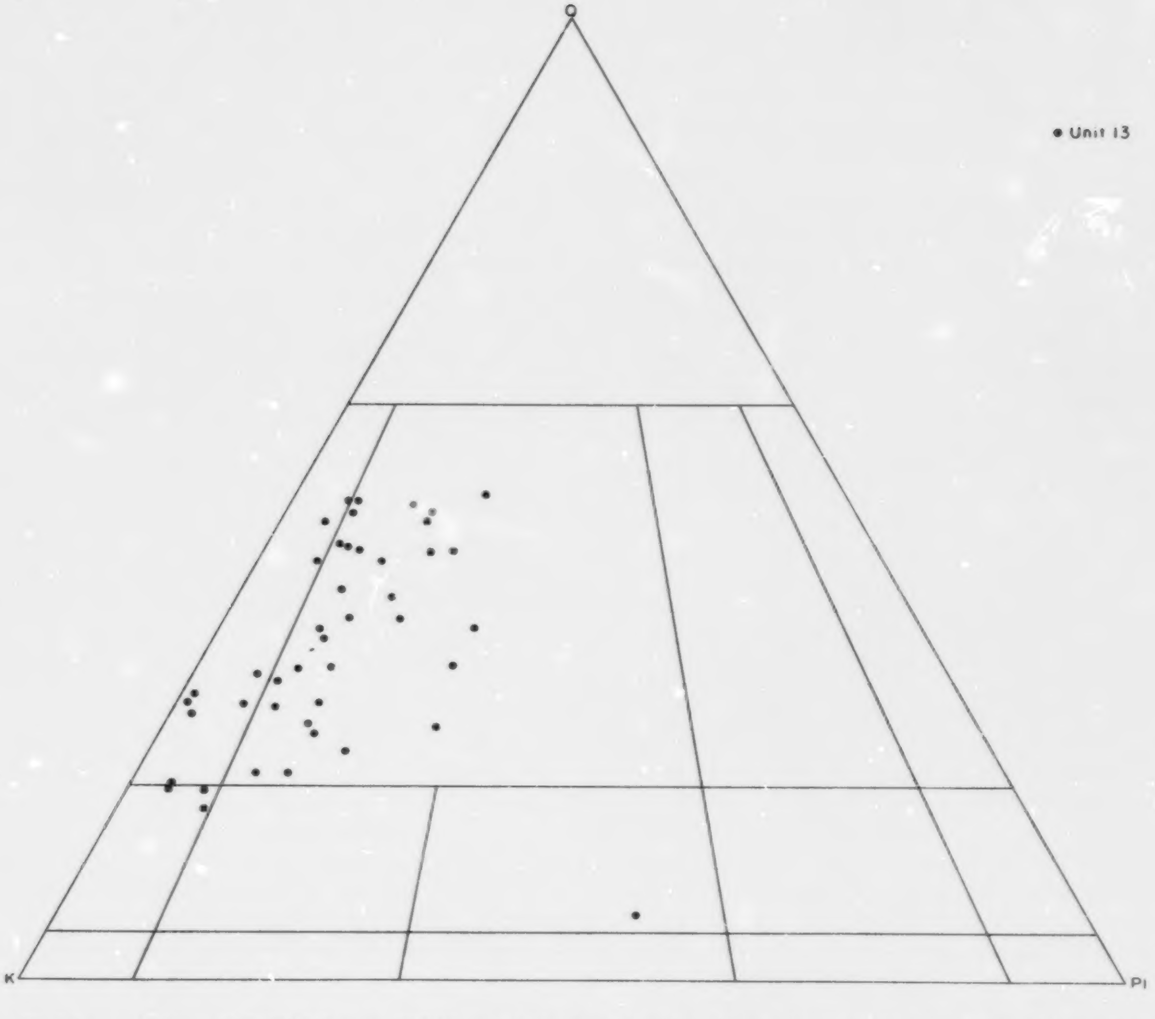


Figure 11: Modal proportions of Q:K:Pl (quartz:K-feldspar:plagioclase) for Unit 13 of the Ackley Granite. Granitoid fields as in Figu

At locality 390, 3 km northwest of Pin Hill, the granite is cataclastically deformed, and veined by epidote. Quartz crystals show extensive sub-grain development and new grain growth along the fractures. The feldspars are fractured and veined by epidote. Biotite is completely altered to chlorite, epidote, and hematite. The deformation is probably related to some local undiscovered fault. The deformed granite is clearly part of the Ackley Granite and not part of an older deformed unit.

The essential mineralogy of Unit 13 is quartz, orthoclase perthite, plagioclase, and biotite. Accessory minerals include apatite, zircon, magnetite, and locally may include sphene, allanite, and rarely hornblende.

Orthoclase perthite is the most prominent mineral in Unit 13. It occurs as phenocrysts and is also found in the groundmass. String albite exsolution lamellae are common. The phenocrysts commonly contain inclusions of quartz, plagioclase, and biotite. Albite mantles occur on a few phenocrysts. Quartz is anhedral and displays undulose extinction. Plagioclase is slightly sericitized and occurs as 1 to 2 cm phenocrysts in a few places but, more commonly, is restricted to the groundmass. Zoning is variably developed. A range from about An_{20} to An_{10} is normal in the zoned plagioclase.

Biotite occurs as fresh flakes and "books," up to 5 mm in diameter. Books of biotite may be up to 3 mm thick. Alteration of biotite to chlorite locally occurs and is generally minor.

Hornblende occurs in minor amounts in the vicinity of the southeastern contact. It is much less abundant than biotite and is less than 0.1% of the mode.

Sphene and allanite are locally visible in hand specimen where they occur as 2 to 5 mm euhedral crystals. Sphene is widespread throughout the unit as 0.2 to 1 mm crystals.

The mineralogy of the aplite is essentially the same as the granite of Unit 13. The main difference is the absence of accessory minerals such as sphene, hornblende, and allanite. Quartz also occurs as a phenocryst phase in a few aplites along with orthoclase and plagioclase.

An important feature of the aplites and microgranites is the presence of locally abundant miarolitic cavities. They show that final crystallization of the granitic magma took place at a high level. However, not all aplites are miarolitic. It is probable that the rocks in the higher ground on Old Woman's Ridge and Sandy Harbour Ridge lay above the critical depth for the existence of a separate vapor phase and the formation of cavities. This may be significant since, in the Sandy Harbour Ridge area (locality 361), 2 to 3 mm flakes of molybdenite occur in a 1 m long quartz vein in miarolitic aplite. R.P. Taylor (personal communication, 1981) discovered minor molybdenite at locality 412, east of Pin Hill. The mineralization occurs in aplite veins which cut coarse grained, porphyritic, biotite granite.

Unit 13 is cut by the only diabase dike (locality 203) found within the Ackley Granite. The dike forms a 6 cm thick, gently dipping sheet of fine grained, plagioclase porphyritic diabase. Seen in thin section, the dike has abundant 0.5 mm plagioclase laths in a highly uralitized groundmass with sketelal ilmenite and minor magnetite. The plagioclase composition is about An_{58}. Normative calculations show that the dike is an olivine tholeiite (Colman-Sadd *et al.*, 1981).

Unit 14 - Massive, Coarse Grained, Equigranular, Biotite Granite

Definition and Extent

Unit 14 consists primarily of pink, massive, coarse grained, equigranular, biotite granite. The term "alaskite" has been used by earlier workers for this unit. However, this usage is incorrect as the rock generally contains more than 10% modal plagioclase. In the southern parts of the unit, south of Big Blue Hill Pond, and in the Long Harbour-Gisborne Lake areas, the unit contains both coarse grained and medium to fine grained granite (subunit 14a). Towards the southern contact the granite becomes increasingly miarolitic. Aplites and quartz veins and pods are common throughout the unit and are particularly abundant at the southern margins. Greisens are extensively developed southwest of Gisborne Lake in subunit 14a. The unit also contains sizable molybdenite prospects near Rencontre Lake, and cassiterite, molybdenite, hematite and pyrite occurrences in subunit 14a, southwest of Gisborne Lake (see Map 1).

Contact Relations

Unit 14 has intruded Precambrian metasediments and metavolcanics of the Long Harbour Group between Gisborne Lake and Belle Harbour. Between Belle Harbour and Big Blue Hill Pond, the unit has intruded clastic sediments of the Precambrian Rencontre Formation and the Cambrian or older Youngs Cove Group (Williams, 1971; Anderson, 1965). The contact with the North West Brook Complex is mainly intrusive but may be faulted west of Big Blue Hill Pond. However, the contact is not exposed. The nature of the contact between Unit 14 and Units 9, 12, and 13 has been described in previous sections.

The metamorphic aureole of Unit 14 is narrow. Williams (1971) reports that the aureole rarely exceeds 400 m (440 yards). The Youngs Cove Group and the Rencontre Formation have been recrystallized, close to the contact, to form a hard black hornfels. Quartz forms fine grained, polygonal aggregates, the feldspars have been extensively converted to muscovite, and biotite has recrystallized to form fresh, ragged flakes. A sample taken from the Little Blue Hill Pond area contains abundant patches of randomly orientated muscovite. The sedimentary rocks of the Long Harbour Group show similar contact metamorphic effects.

The felsic volcanic rocks of the Long Harbour Group are extensively recrystallized, close to the contact with the Ackley Granite, to form fine grained aggregates of quartz and feldspar. The mafic volcanics exposed in the area southwest of Gisborne Lake (see O'Brien *et al.*, 1980b) contain randomly orientated tremolite-actinolite which formed during contact metamorphism. The gabbro and diabase of the Cross Hills Complex show similar effects.

The contact between Unit 14 and the metasedimentary and metavolcanic rocks is generally sharp, with very few dikes or xenoliths in the contact zone. Thin aplite dikes, less than 5 cm in width, which extend up to 5 m from the contact, are normally the only penetration of the country rocks shown by the granite. However, in the Rencontre Lake area, much larger quartz-feldspar porphyry dikes cut the granite-rhyolite contact. In the Little Blue Hill Pond area, large xenoliths, which commonly exceed 10 m in length, occur in a 200 m wide zone which is composed of a mixture of granite dikes and veins, and stoped blocks of sandstone.

Quartz-feldspar porphyry dikes, up to 4 m in width, and possibly related to the Ackley Granite are scattered throughout the Fortune Bay area (Williams, 1971). It is possible, however, that they are related to some of the other granites in the Fortune Bay area such as the Belleoram Granite, around which porphyry dikes are apparently more abundant (see Williams, 1971).

Lithologies

More than 90% of Unit 14 consists of pink, massive, coarse grained, equigranular, biotite granite. The remainder (subunit 14a) is locally miarolitic, medium to fine grained granite which is mainly concentrated in the southwestern and southeastern lobes of the unit (see Table 10, and Figure 12). The granite of Unit 14 essentially contains quartz, orthoclase perthite, plagioclase, and biotite. Accessory minerals may include magnetite, apatite, zircon, sphene, allanite, and rarely cassiterite. Secondary minerals are sericite and muscovite, hematite (after magnetite and locally plagioclase), rare fluorite, minor chlorite and hematite after biotite.

The unit is coarse grained with an average crystal size of 5 mm to 1 cm. Phenocrysts are rare and consist of subhedral orthoclase perthite phenocrysts up to 2 cm in length.

Thin section examination shows the texture of Unit 14 to be hypidiomorphic granular, with interlocking crystals of quartz, orthoclase perthite and plagioclase. Locally, granophyric intergrowths are present. These increase in abundance within 1 km of the southern contact. Locally, at the southern contact between Unit 14 and the Precambrian units, the rock is a medium grained, porphyritic granophyre with phenocrysts of orthoclase perthite. The granite, at the contact of subunit 14a and the Precambrian units, is more commonly fine to medium grained, hypidiomorphic granular granite, with rare granophyric intergrowths.

Quartz is commonly anhedral and strained. Small quartz crystals commonly occur as inclusions in the perthite. Quartz lines the miarolitic cavities which are common near the southern contact of Unit 14. Fine grained, drusy quartz forms 0.1 mm wide veinlets which have filled open space in the granite. Where this space was wider than normal a cavity is left which is lined with terminated quartz crystals. The miarolitic cavities, however, are commonly much larger and locally reach 2 cm. In many areas along the contact between Gisborne Lake and Belle Harbour, pockets of quartz occur which may reach 1 m in diameter. These commonly have a cavity towards the center. Some quartz pockets contain a single large quartz crystal, which may reach 30 cm in diameter, and contain hexagonal cones filled with granite or sericite. These are particularly well developed at the Crow Cliff-Dunphey Brook molybdenite showing.

The dominant feldspar is orthoclase perthite. The perthite contains about 10% albitic exsolution lamellae. Towards the southern contact the porportion of albite lamellae increases to about 50% in places, and modal plagioclase is often less than 2%. In a few areas the perthite has a 1 to 2 mm wide mantle of albite. Zones of micrographic intergrowths are found within the perthite in many areas. Alteration of the feldspars to sericite is highly variable. Minor exsolution of hematite gives the perthite a red color.

Plagioclase varies in proportion from about 30% to less than 2%. The crystals are commonly subhedral with well developed twinning. Anorthite content is about An_{15} to An_{10}. Zoning is variably developed and commonly only a thin mantle of less calcic plagioclase is seen. Fine grained sericitic alteration of the plagioclase is ubiquitous and is generally concentrated in the more calcic cores of the plagioclase.

Biotite commonly occurs as fresh flakes and thin books up to 4 mm in diameter. The size and proportion of the biotite flakes varies greatly and in many areas the flakes are less than 1 mm in diameter and less than 1% of the mode. Locally the biotite is almost opaque in thin sections. Inclusions of zircon with associated haloes are common in the biotite. Alteration of the biotite is variable. Alteration to dark green chlorite and magnetite is common. In places, the biotite is altered to sericite.

TABLE 10: MODAL ANALYSES OF UNIT 14

a. Subunit 14a - southwest of Gisborne Lake

SAMPLE	329	330	331	332	334	339	716	717
Quartz %	39.7	40.1	33.6	53.0	46.5	34.6	46.6	45.3
K-feldspar	49.0	42.9	44.0	44.0	30.6	57.8	43.3	45.0
Plagioclase	8.9	14.8	18.5	0.7	21.5	3.8	6.9	8.1
Biotite	1.7	2.2	3.8	2.2	1.3	1.2	3.2	1.0
Muscovite	-	-	-	-	-	-	-	-
Hornblende	-	-	-	-	-	-	-	-
Others	0.7*	0.5x	-	-	-	3.6**	1.0x	-

* Sericite ** Sericite 1.2, Sphene 0.7, Epidote 0.3, Opaques 0.3
x Opaques

b. Subunit 14a including Unit 14 north of Rencontre Lake

SAMPLE	259	608	642
Quartz %	28.7	40.5	30.7
K-feldspar	53.7	46.5	49.1
Plagioclase	11.6	12.5	19.0
Biotite	5.5	0.5	1.2
Muscovite	-	-	-
Hornblende	-	-	-
Others	0.6x	-	-

x Opaques

c. Northern portions of Unit 14

SAMPLE	267	268	443	452	456	545	550	557
Quartz %	36.0	42.3	39.6	41.6	42.8	17.1	44.5	42.2
K-feldspar	52.0	42.8	37.2	48.8	42.0	70.1	43.7	38.0
Plagioclase	8.6	10.1	20.7	4.4	10.9	7.5	11.3	14.1
Biotite	3.4	4.8	2.4	5.0	4.3	5.3	0.5	5.7
Muscovite	-	-	-	-	-	-	-	-
Hornblende	-	-	-	-	-	-	-	-
Others	-	-	-	-	1.4***	-	-	-

*** Epidote 0.6, Sphene 0.6

SAMPLE	576	578	581	586	666	706	712	727
Quartz %	34.1	35.5	30.4	45.0	29.2	29.4	35.3	45.5
K-feldspar	42.7	53.2	60.7	44.4	52.8	52.3	48.0	19.9
Plagioclase	19.6	8.4	7.7	5.3	18.0	16.3	9.8	31.8
Biotite	3.6	3.0	1.2	5.3	Tr	2.0	6.9	0.5
Muscovite	-	-	-	-	-	-	-	-
Hornblende	-	-	-	-	-	-	-	-
Others	-	-	-	-	-	-	-	2.4++

++ Opaques 0.9, Sericite 0.9, Epidote 0.5

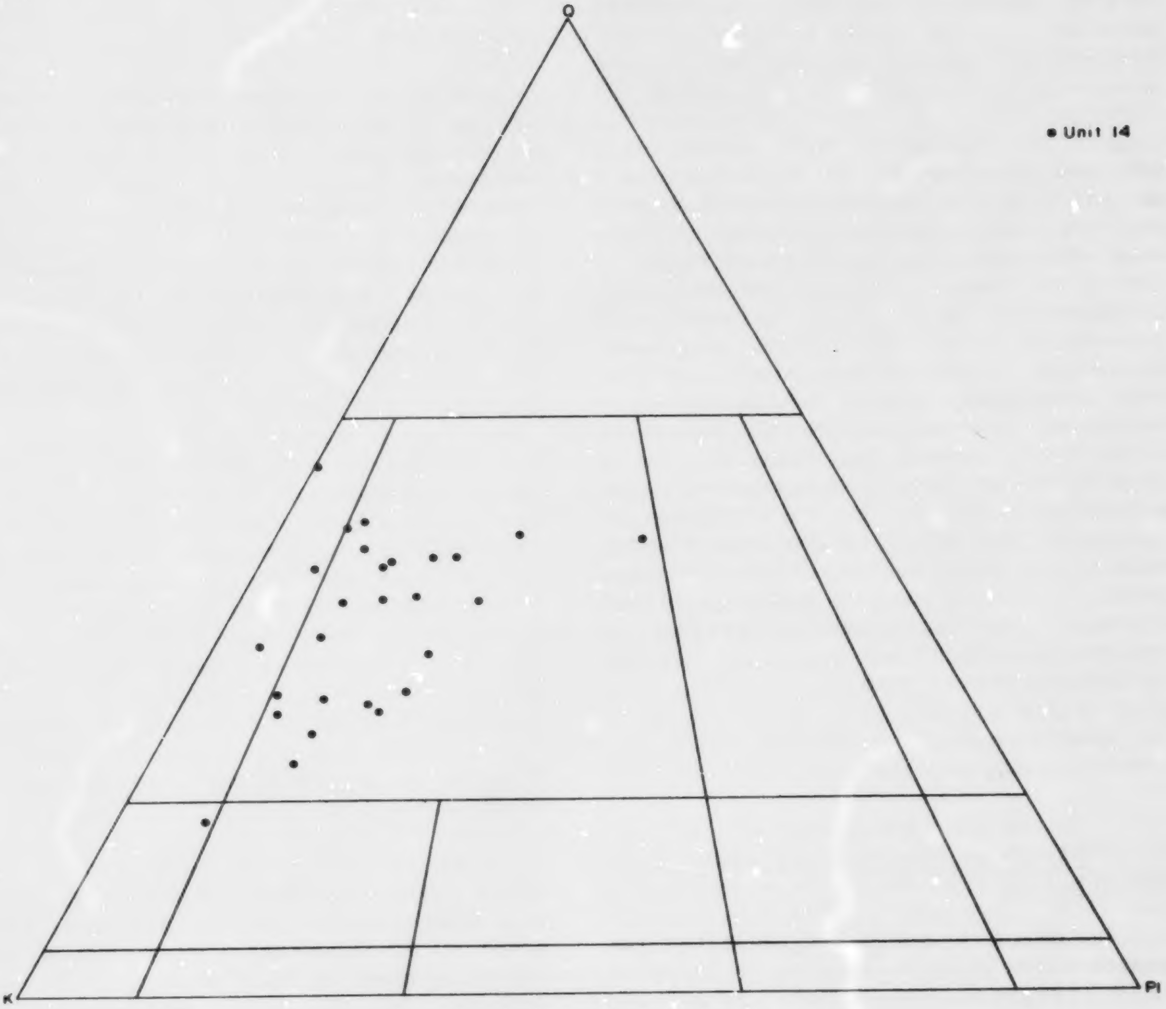


Figure 12: Modal proportions of Q:K:Pl (quartz:K-feldspar:plagioclase) for Unit 14 of the Ackley Granite. Granitoid fields as in Figure 3.

Sphene is randomly distributed throughout the unit but is commonly absent. The sphene crystals are euhedral and locally are highly altered. Zircon occurs locally as relatively large euhedral crystals up to 0.5 mm in length. Skeletal magnetite is locally abundant in the granite close to the contact. Fluorite occurs as a rare accessory in subunit 14a, southwest of Gisborne Lake. Secondary muscovite is common at the Wylie Hill molybdenite prospect where it occurs as books 1 to 3 mm thick and as flakes associated with pyritic alteration patches. This muscovite has possibly replaced biotite. Throughout subunit 14a, to the southeast of Gisborne Lake, minor interstitial muscovite is present. This may have formed as a sub-solidus phase, as the high level emplacement of the granite precludes crystallization of muscovite from the magma. Molybdenite is a prominent accessory mineral at the molybdenite showing in the vicinity of Rencontre Lake where it has crystallized with the granite melt (see also Whalen, 1976, 1980), and occurs with quartz and feldspar as interlocking grains in aplite, pegmatite, and as disseminations in coarse grained granite.

Quartz veins and aplite dikes are common throughout the main part of Unit 14.

Mineralization (in Unit 14 apart from subunit 14a)

In Unit 14 specular hematite-rich quartz veins cut the granite at locality 1148 (Figure 57). The veins are parallel, about 3 to 5 cm wide, and up to 4 m in length. At Long Harbour (locality 42), a minor narrow zone of fault-brecciated granite is cemented by red hematite. Anderson (1964) reports molybdenite-bismuthinite mineralization in a quartz vein about 180 m (200 yards) west of Hungry Grove Pond. "The quartz vein cuts granite, ranges in width from 8 to 14 inches over an exposed length of 20 feet, strikes N5°E, dips vertically, and contains about 10 percent molybdenite and minor bismuthinite." This vein was not relocated during this project and detailed assessment work in the area carried out by Saunders (1980) for Falconbridge Nickel Mines also failed to locate the vein.

Subunit 14a

This unit is fine to medium grained, and is locally highly porphyritic with 5 to 10 mm phenocrysts of quartz and feldspar. The change in grain size from coarse to medium and fine grained is gradual in the area southwest of Gisborne Lake. North of Rencontre Lake, the area is underlain by variably textured granite, which is particularly variable at a local level, and in the vicinity of the molybdenite showings (Whalen, 1976, 1980).

Southwest of Gisborne Lake, subunit 14a is dominantly medium to fine grained, biotite granite with minor, medium-coarse grained, biotite granite. Quartz veins and pods, aplite dikes, and topazite greisen veins are common. Gray micaceous greisen zones also occur near the southern end of Sage Pond. The quartz veins vary in length from about 5 cm to about 5 m.

Mineralization in Subunit 14a, Southwest of Gisborne Lake

Some of the quartz veins, which cut subunit 14a southwest of Gisborne Lake, are mineralized. Near Locality 717, close to the contact, about 500 m^2 of coarse grained biotite granite is cut by numerous quartz veins and pods which locally contain coarse molybdenite flakes and rosettes about 1 cm in diameter. Most of the quartz veins and pods are barren but some contain about 5% molybdenite in hand specimen size samples. Aplite and topazite greisen veins, up to 30 m long and 5 m in width, are particularly common in the eastern half of subunit 14. These veins are concentrated near the contact, and are more extensive on higher ground. This suggests that proximity to the contact, whether roof or wall, is an important factor in the location of these veins. The topazite greisens have a texture similar to the aplites and a few contain abundant sericite and kaolin(?) probably after feldspar. A prominent feature of the topazite greisens is the common occurrence of specular hematite, and pyrite and molybdenite in some of the veins. Specular hematite occurs in many of the topazite greisens between Old Tilt Pond and Taylors Mountain Pond, as disseminated skeletal grains which locally range from 1 mm to 1 cm wide veins. Thin sections of several topazite greisens contain trace amounts of cassiterite which occurs as interstitial subhedral crystals about 0.1 m long. The concentration of cassiterite in the topazite greisens which have been examined is less than 0.1%.

To the southwest of Sage Pond, McLachlan (1953) and Ricketts and Bumgarner (1954) described eight showings of pyrite-molybdenite in rocks which they considered to be sedimentary quartzite roof pendants. These "roof pendants" are now considered to be very large topazite greisen veins. The highest grade of molybdenite mineralization was estimated at 0.4% MoS_2 by Ricketts and Bumgarner (1954). Re-examination of the showings did not show extensive mineralization of such high grade. Pyrite content reaches about 10%. Abundant pyrite with trace amounts of molybdenite occurs in a vuggy topazite vein near the eastern margin of subunit 14a (locality 221177, Map 2a). The mineralization southwest of Gisborne Lake is discussed further in the section on geochemistry of the mineralized area southwest of Gisborne Lake.

Subunit 14a, North of Rencontre Lake

Granite of subunit 14a, in the area north of Rencontre Lake, accounts for about 50% of the samples taken from this area. Rocks of subunit 14a are randomly distributed throughout the area and are not concentrated around the contact of the granite. In many locations dikes and pods of medium grained, quartz-feldspar-biotite porphyritic granite occur in coarse grained, biotite granite. Minor pods of quartz-feldspar pegmatite are also scattered throughout the area. To the west and northwest of Little Blue Hill Pond, the rock is uniformly medium grained, equigranular biotite granite.

Mineralization in Subunit 14a, North of Rencontre Lake

Molybdenite occurs north of Rencontre Lake within subunit 14a. The four major occurrences are found close to the granite-metavolcanic contact within finer grained granite phases. The occurrences are, from west to east, Motu, Ackley City, Crow Cliff-Dunphey Brook, and Wylie Hill. Two other occurrences occur north of Rencontre Lake. These are Franks Pond, which is located about 5 km north-northwest of Rencontre Lake, and North Hill which is about 300 m northwest of Rencontre Lake (Bradley, 1955a). The North Hill showing is very minor and consists of flakes of molybdenite in quartz veins which occur in talus at the foot of a cliff. Bradley (1955a) traced these to their probable source and discovered no significant mineralization in place. A similarity between this showing and the Franks Pond showing was also noted by Bradley (1955a).

The molybdenite showings were originally discovered in 1882 and sporadic evaluation work has been carried out since. The Wylie Hill and Ackley City showings have received most attention with trenching, extensive drilling and underground workings, particularly at Ackley City.

The more important early reference works are Smith (1936), White (1939), Bradley (1955a) and Nolan (1969).

Motu Showing

Local Geology (from Whalen, 1980 with minor amendments): "The Motu showing is 2.3 km west of Rencontre Lake

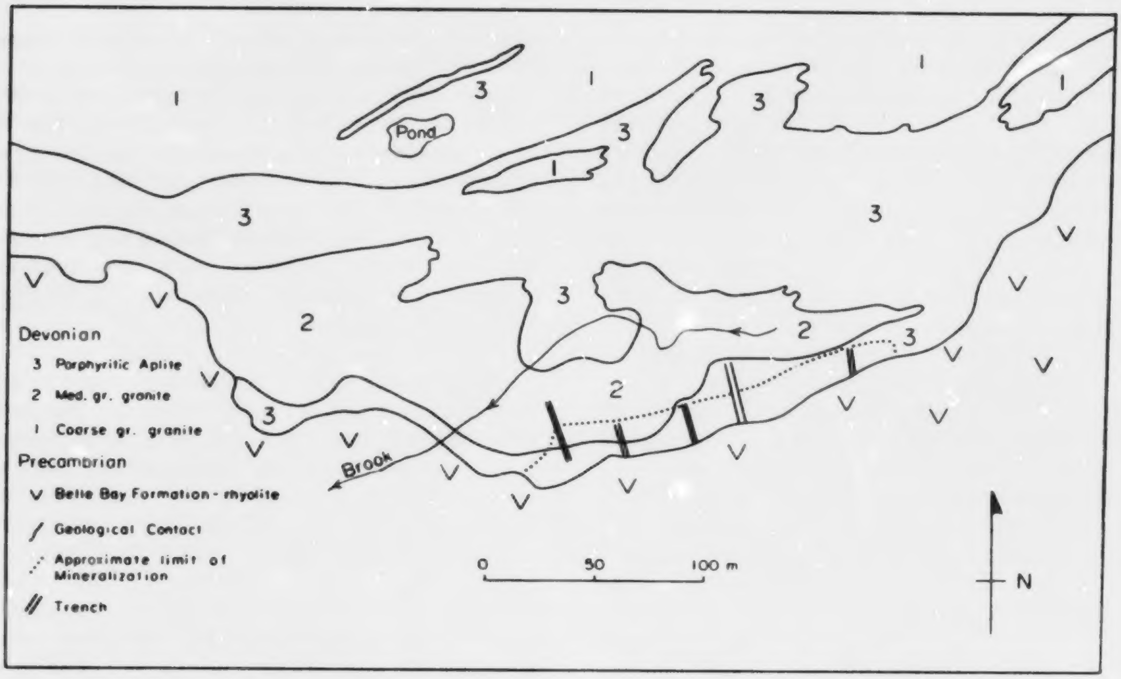

1
3
1
3
1
1
Pond
3
1
3
3
2
3
2
3
2
3
Brook
Devonian
3 Porphyritic Aplite
2 Med. gr. granite
1 Coarse gr. granite
Precambrian
V Belle Bay Formation - rhyolite
/ Geological Contact
Approximate limit of Mineralization
// Trench
0
50
100 m
N

Figure 13: Geological map of the Motu molybdenite showing, west of Rencontre Lake (from Whalen, 1976).

at the contact between the Ackley City batholith and rhyolite of the Belle Bay Formation (Figure 13). Mapping of the showing has outlined two other intrusive units, a medium grained leucogranite and an aplite. Sharp contacts have been observed between these two and alaskite, but not between each other. This is not due to lack of outcrop, therefore, leucogranite and aplite may be mutually gradational over a short distance. The batholith-rhyolite contact varies in strike but dips approximately 30°S, while sheeted joints have the same dip and strike 085°.

"The aplite is a miarolitic, fine-grained (average 0.2 mm) light pink rock, which has scattered anhedral quartz phenocrysts (2-4 mm) and is composed essentially of perthite, albite, and quartz. The leucogranite differs only in being coarser grained (average 5 mm) and in having rare fibrous biotite aggregates. Both intrusive phases contain abundant granophyric intergrowths of perthite and quartz.

"Molybdenite occurs mainly within the finer-grained intrusive phases along a length of approximately 175 m and a width of 25 m adjacent to the granite-rhyolite contact."

Mineralization: The molybdenite occurs as patches of rosettes up to 20 cm in diameter. The rosettes are up to 1 cm in diameter. Molybdenite also occurs in miarolitic cavities and forms rosettes from 1 mm to 5 mm in diameter. Molybdenite flakes, from 1 mm to 4 mm in diameter, are also scattered throughout the porphyritic aplite within the mineralized zone. Pyrite is scattered throughout the showing area and is generally less than 1%. Assessment of the showing has been carried out sporadically over 50 years. Five trenches were cut at 100' (30 m) intervals from the contact to the limit of mineralization (Figure 13). Smith (1936) reports a grade of 0.32% Mo over a length of 6 m based on the average of two samples. Smith (1936) considered the zone of mineralization to be steeply dipping. However, later reports (Bradley, 1955a; Whalen, 1976, 1980) and diamond drilling (Consolidated Toronto Development Corp., 1958) show that the deposit dips at 30° to 45° to the south, roughly parallel to the contact, and that the mineralization dies out at a depth of about 30 m (Figure 14). The highest grade reported by Consolidated Toronto Development Corp. is 0.09% Mo. Other features noted in the Consolidated Toronto Development Corp. (1958) drill logs are the presence of locally high concentrations of "muscovite," up to 40% in places, commonly associated with "greisen." "Greisened granite" was reported in the five holes drilled. "Kaolinization" was also reported and appears to be more abundant in the three eastern holes. In the easternmost drill hole (M5) at the edge of the zone of molybdenite mineralization, the drill logs record the presence of "white granite" which was encountered at a down-hole depth of 80 feet and continues, mixed with minor pink granite, to the end of the hole at 152 feet. No chemical analyses are reported from this white granite but it is clearly an altered granite. Greisen, kaolinization, high concentrations of muscovite, and white granite have not been reported from surface mapping at Motu. The possibility of tin mineralization associated with this alteration is clear. A sample of fresh, pink, molybdenite-bearing granite and a sample of fresh, pink, barren granite taken from the area of the trenches at Motu have been analysed for tin (Dickson, 1981). Tin values were low at 6 g/t and 3 g/t respectively (Table 15). However, the possibility of anomalous tin values from the altered sections of the showing clearly exists. The location of the drill core is unknown.

Ackley City Showing

Local Geology (from Whalen, 1980 with minor amendments): "The Ackley City showing is on the west side of Rencontre Lake in an embayment of the granite into the rhyolite (Figure 15). Detailed mapping outlined a number of intrusive rock types (pegmatite, fine grained leucogranite, medium grained leucogranite and aplite), other than the normal alaskite. Contacts between these different intrusive units range from sharp to gradational. Most of the finer-grained and pegmatitic intrusive material appears to be younger than the alaskite.

"The rhyolite-batholith contact strikes at 075° and dips 45° to 50°S to form the hanging wall of the molybdenite zone. To the east, near the lake, the contact steepens markedly then swings northwards along the side of the lake. The largest area of pegmatite (which is similar to that which will be described in detail for the Dunphey Brook - Crow's Cliff showing) occurs west of the mineralized zone, but small pods were observed near the batholith-rhyolite contact in many locations. The fine to medium-grained leucogranite and aplite are similar to that described from the Motu showing. An unusual feature, however, is the pronounced inversion of perthite to microcline in these units, particularly in the mineralized zone. A red pegmatitic aplite is common. It contains abundant, irregular to ovoid, pegmatitic pods or clots 2 to 20 mm in diameter, whose outer fringe of graphically intergrown perthite and quartz grades radially inwards towards a quartz-filled centre or a miarolitic cavity lined with chlorite.

"The prospect is approximately 42 m long by a maximum of 12 m wide, bounded by rhyolite (south), Rencontre Lake (east), and progressively lower grade rock (west and north). Molybdenite occurs as disseminations, pods, and fracture fillings. Disseminated molybdenite occurs as 2 to 5 mm flakes

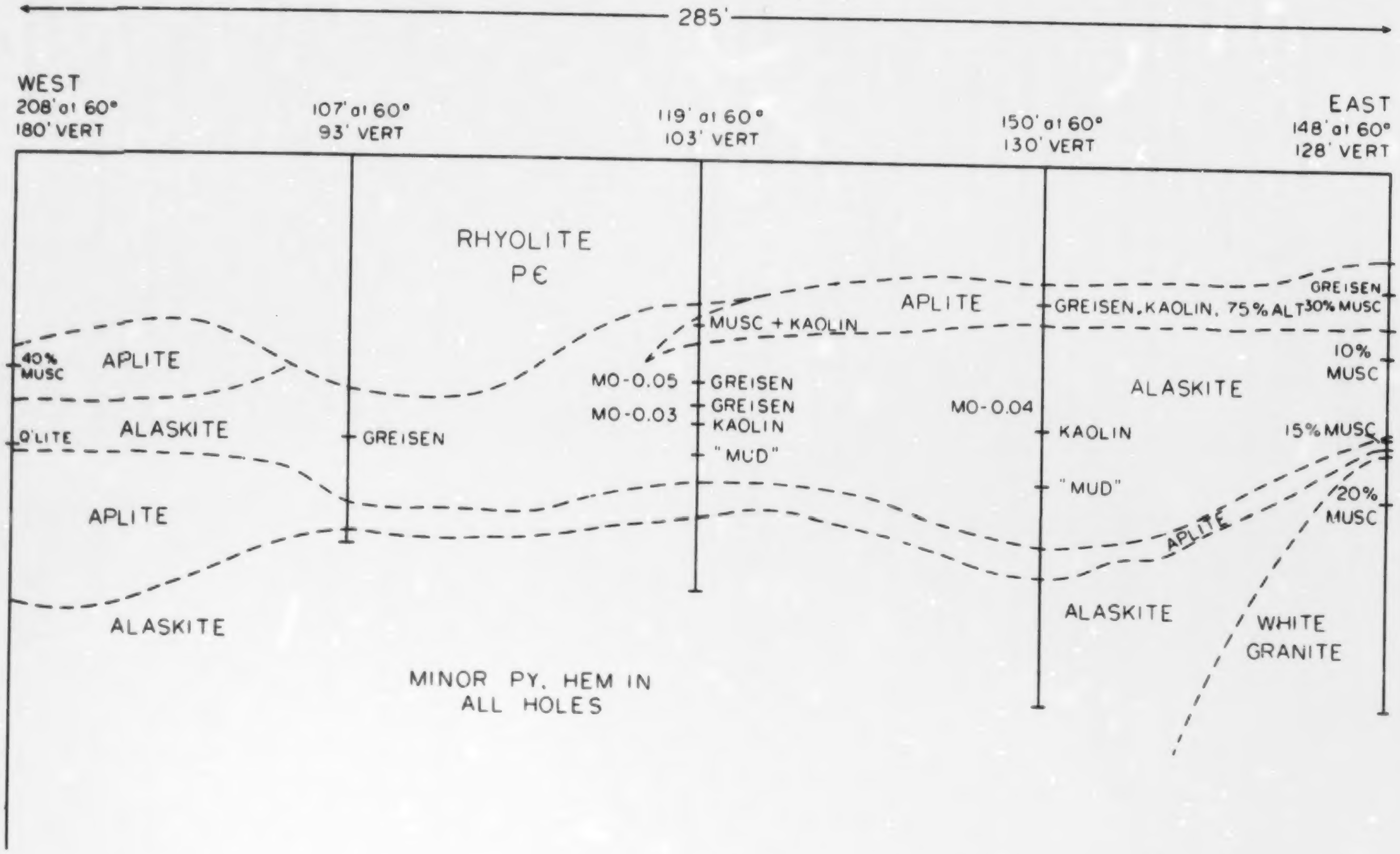

285'
WEST
208' at 60°
180' VERT
107' at 60°
93' VERT
119' at 60°
103' VERT
150' at 60°
130' VERT
EAST
148' at 60°
128' VERT
RHYOLITE
PЄ
40% MUSC
APLITE
O'LITE
ALASKITE
APLITE
ALASKITE
GREISEN
MUSC + KAOLIN
MO-0.05
MO-0.03
GREISEN
GREISEN
KAOLIN
"MUD"
APLITE
MO-0.04
GREISEN, KAOLIN, 75% ALT
KAOLIN
"MUD"
ALASKITE
GREISEN
30% MUSC
10% MUSC
15% MUSC
20% MUSC
APLITE
ALASKITE
WHITE GRANITE
MINOR PY, HEM IN ALL HOLES

Figure 14: Interpretation of drill log data from five drill holes as reported by Consolidated Toronto Development Corporation (1958).

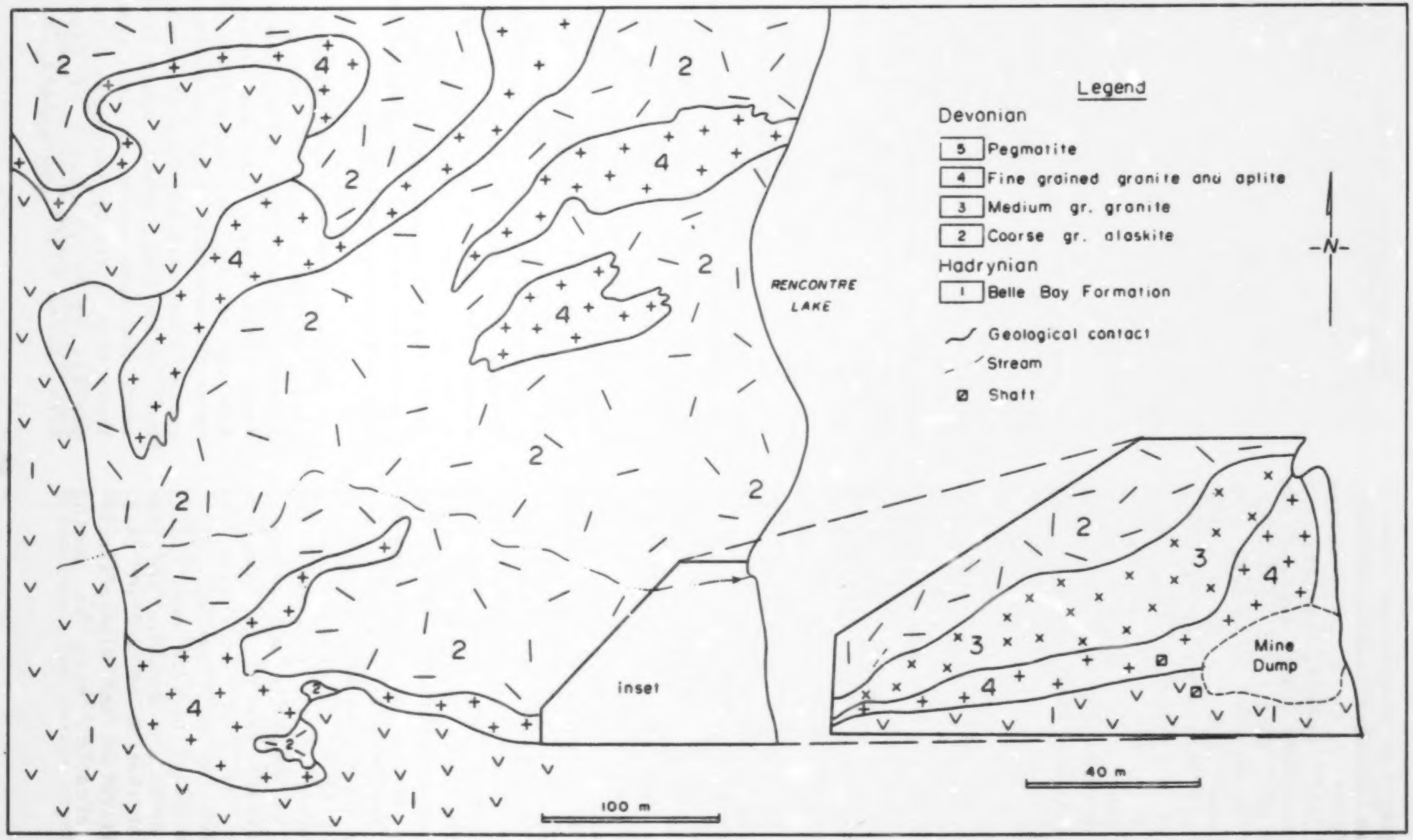

Legend
Devonian
5 Pegmatite
4 Fine grained granite and aplite
3 Medium gr. granite
2 Coarse gr. alaskite
Hadrynian
1 Belle Bay Formation
Geological contact
Stream
Shaft
-N-
RENCONTRE LAKE
inset
100 m
40 m
Mine Dump
1
2
3
4

Figure 15: Geological map of the Ackley City molybdenite showing (modified from Whalen, 1976).

occupying quartz or plagioclase sites in an otherwise unaltered intrusive host. It also forms 2 to 3 cm rosettes associated with quartz, barite, and calcite in secondary quartz segregations and pegmatite pods. In addition, molybdenite accompanied by quartz also fills fractures of 0.2 - 20 mm width, which cut all intrusive units. Some disseminated molybdenite is closely associated with muscovite alteration; however, there is not a close correlation between muscovite alteration and mineralization. Small areas of deep purple fluorite occur both as disseminations within the intrusion and on fractures. The rhyolite immediately adjacent to the mineralized zone, and within about 100 m of it, is cut by closely spaced pyrite- and chlorite-filled fractures. Sphalerite, chalcopyrite, and pyrrhotite have been reported as very rare associated sulphide minerals (White, 1939).

"Varied alteration associated with mineralization is quite extensive. The main alteration is silicification of the host to form quartz segregations. These are irregular pods or patches of milky white quartz that range in width from a few centimetres to more than a metre. They are characterized by massive quartz cores grading outwards through quartz with specks of pink feldspar to texturally recognizable host rock with extensive secondary quartz. These areas of silicification form belts separated by intrusive host containing some secondary quartz. Irregularly shaped and distributed, medium to coarse-grained patches of replacement muscovite are also closely associated with mineralization. Intensity of alteration varies from replacement of all K-feldspar and plagioclase by muscovite and augmentation of primary quartz to complete replacement of the intrusion by coarse-grained (up to 1 cm) muscovite. Areas of secondary biotite near quartz veins, and secondary monazite are also present. Distribution of all of these types of alteration and mineralization is highly erratic, with no zoning apparent."

Mineralization: Extensive drilling, trenching and underground workings have been carried out at Ackley City (Smith, 1936; Quinn, 1944; Nolan, 1969). Smith estimated the "reasonably proven" reserves at Ackley City to be 125,000 tons of above 0.31% MoS_2. McKinstrey (1938) estimated reserves of 64,600 tons at an average grade of 0.58% MoS_2. This was based on 23,600 tons at 0.87% MoS_2 above the adit level and 41,000 tons at 0.38% MoS_2 from the adit to the 60 foot level. McKinstrey's figures "included no assumption as the the amount of ore below the deepest level" (Nolan, 1969). Nolan (1969) notes that McKinstrey "made no allowance for a continuation of high grade mineralization toward the lake, beyond the eastern extremity of the underground workings." Nolan (1969) suggested a tonnage between that of McKinstrey and Smith "in the order of 80,000 tons of 0.6% MoS_2."

Drilling by Norlex Mines Ltd. (Nolan, 1969) was considered by Nolan to have undercut the best mineralization although local high concentrations of MoS_2, mainly in aplite, were encountered.

The highest concentrations of molybdenite are apparently structurally controlled. The dip of the rhyolite granite contact is irregular and, where such irregularities form an inverted trough, mineralization is enhanced. Where the dip of the contact is uniformly gentle, mineralization is generally low grade and where the dip of the contact is steep, the mineralization dies out rapidly with depth.

Greisen and muscovitization have been described from the Ackley City showing. Whalen (1980) dated a muscovite sample from Ackley City and obtained a K/Ar age of 338±7 Ma. White (1939, 1940) notes the presence of aplite which has a muscovitized core and silicified margin. Gray, 6 cm long, ovoid, muscovite-rich xenoliths also occur in the granite. These bear a strong resemblance to the greisen veins southwest of Gisborne Lake. Nolan (1969) considers "highly siliceous rock" encountered in two drill holes to be greisen. The presence of these highly altered rocks supports the possibility of tin mineralization. A sample taken 200 m to the west of Ackley City (locality 252), however, showed only 1 g/t tin (Colman-Sadd *et al.*, 1981). A sample of molybdenite-bearing granite from Rencontre Lake (presumably Ackley City) was reported by Mulligan (1975, page 130) to contain 68 g/t tin. Clearly re-analysis of the Ackley City showing for tin is warranted.

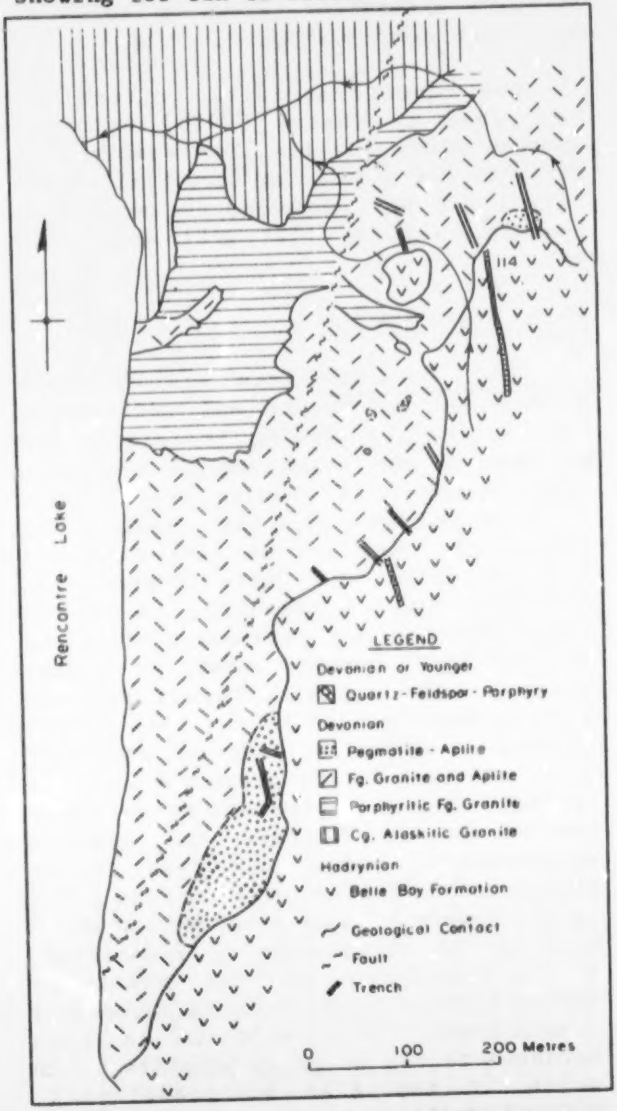


Figure 16: Geological map of the Crow Cliff - Dunphey Brook molybdenite showing, Rencontre Lake (from Whalen, 1976).

Dunphey Brook-Crow's Cliff Showing

Local Geology (from Whalen, 1980 with minor amendments): "The Dunphey Brook-Crow's Cliff showing is located on the northeast side of Rencontre Lake adjacent to the granite - Belle Bay Formation contact (Figure 16). Mapping of the area has outlined a number of intrusive rock types (quartz-feldspar porphyry, pegmatite, leucogranite, and aplite) other than the alaskite that borders these units to the north. The quartz-feldspar porphyry (a post-mineralization intrusive phase) occurs as dikes that cut both the rhyolite and granite. The contact between alaskite and leucogranite is sharp and dips about 20° south. The leucogranite is porphyritic and varies in both grain size and matrix and abundance of phenocrysts, both of which are greatest near the alaskite contact. It probably grades into the aplite phase, with the mapped contact representing the absence of phenocrysts. The pegmatite bodies occur in the form of sills, which are adjacent to and dip parallel to the rhyolite contact, a feature readily apparent from relative topographic relief. This rhyolite-granitoid contact has a general strike of 020° and varies in dip from 60°S below Crow's Cliff to 15°S at Dunphey Brook and parallels flow layering in the rhyolite. The showing is cut by a fault, which strikes at 025° and is marked by an escarpment, the east side of which is approximately 200 m higher than the west.

"The quartz-feldspar porphyry is a medium grained, reddish brown rock consisting of bypyramidal quartz (2-6 mm) and perthite (3-8 mm) phenocrysts in a very fine grained matrix. The leucogranite and aplite are similar to those at the other showings. Areas that are strongly miarolitic and others of pegmatitic aplite are common. The main pegmatites consist of large (maximum 50 cm diameter) milky-white quartz crystals that are surrounded by medium-grained (1 to 2 cm), masses of perthitic orthoclase. The quartz crystals exhibit prismatic as well as pyramidal faces; the presence of the former indicates that they crystallized as the low (alpha) variety of quartz. Most quartz crystals contain almost regularly spaced thin zones of K-feldspar which outline the quartz crystal at different stages of growth in the C direction. The crystals tend to part at these zones, resulting in the effect of interlocking quartz terminations stacked on top of each other. Many of the quartz crystals have vertical orientations with termination pointing downwards and also increase in diameter in this direction, both of which suggest they grew downwards from the now eroded roof. There are also zones of massive milky quartz which apparently underlie or are bordered by zones of euhedral quartz with its interstitial K-feldspar. Apart from these large pegmatite bodies, there are also similar, smaller (less than 10 cm to several metres) pegmatite pods irregularly distributed between and adjacent to the large bodies.

"Minor breccia dikes and veins, which probably represent degassing breccias (tuffisites), cut the alaskite near its contact with the porphyritic aplite. These are up to 50 cm wide, but usually 0.2 to 2 cm wide. They consist of angular to subrounded fragments of host rock in a granulated rock flour matrix.

"*Mineralization:* Molybdenite occurs mainly as very coarse grains within the large pegmatite quartz crystals or the massive quartz that underlies them. It forms irregular, almost flat pods. The orientation of molybdenite crystals indicates that they grew parallel to the long direction of the pod, possibly as a migrating front of precipitation. Molybdenite flakes were also noted in the previously described K-feldspar zones in quartz crystals, possibly due to distinct intervals of molybdenite precipitation. There is also scattered minor fine-grained molybdenite within the aplites surrounding the pegmatites."

Other Mineralization: Bradley (1955b) described eight minor occurrences of galena, sphalerite, pyrite and fluorite which occur in dikes which range in composition from fine gabbro and diorite to aplite. The dikes cut the marginal aplite in the Dunphey Brook area but do not cut the rhyolite. Bradley (1955b) did not consider the showing to be economic. Whalen (1976) notes that chalcopyrite, galena, and fluorite mineralization is associated with fractures which have quartz-sericite alteration haloes up to 25 cm on either side.

The quartz-sericite alteration described by Whalen (1976) warrents further study for tin. One sample from close to the contact at Crow Cliff shows only 1 g/t tin. However, the rock also contains high Mo (121 g/t) and U (19 g/t).

Wylie Hill Showing

Local Geology (from Whalen, 1980 with minor amendments and additions): "The Wylie Hill showing is located 2.5 km east of the north end of Rencontre Lake, again in a granite protuberance into rhyolite of the Belle Bay Formation. Detailed mapping outlined five intrusive rock units (Figure 17), quartz-feldspar porphyry, a post-mineralization unit previously described for the last showing, occurs as a dike which trends north-northwest through granite and rhyolite to the east of the showing. A number of areas of pegmatite occur adjacent to the granitoid-rhyolite contact. Quartz aplite ocuurs as small bodies in the eastern and western molybdenite zones and has sharp intrusive contacts with aplite. The aplite covers a large area, within which most of the molybdenite is restricted. It is bordered on the north by leucogranite with which it is apparently gradational. This unit is in turn bordered to the north by alaskite, with which it may also be gradational. Diamond drill hole data (Nolan, 1969) suggest the mineralized zone and these

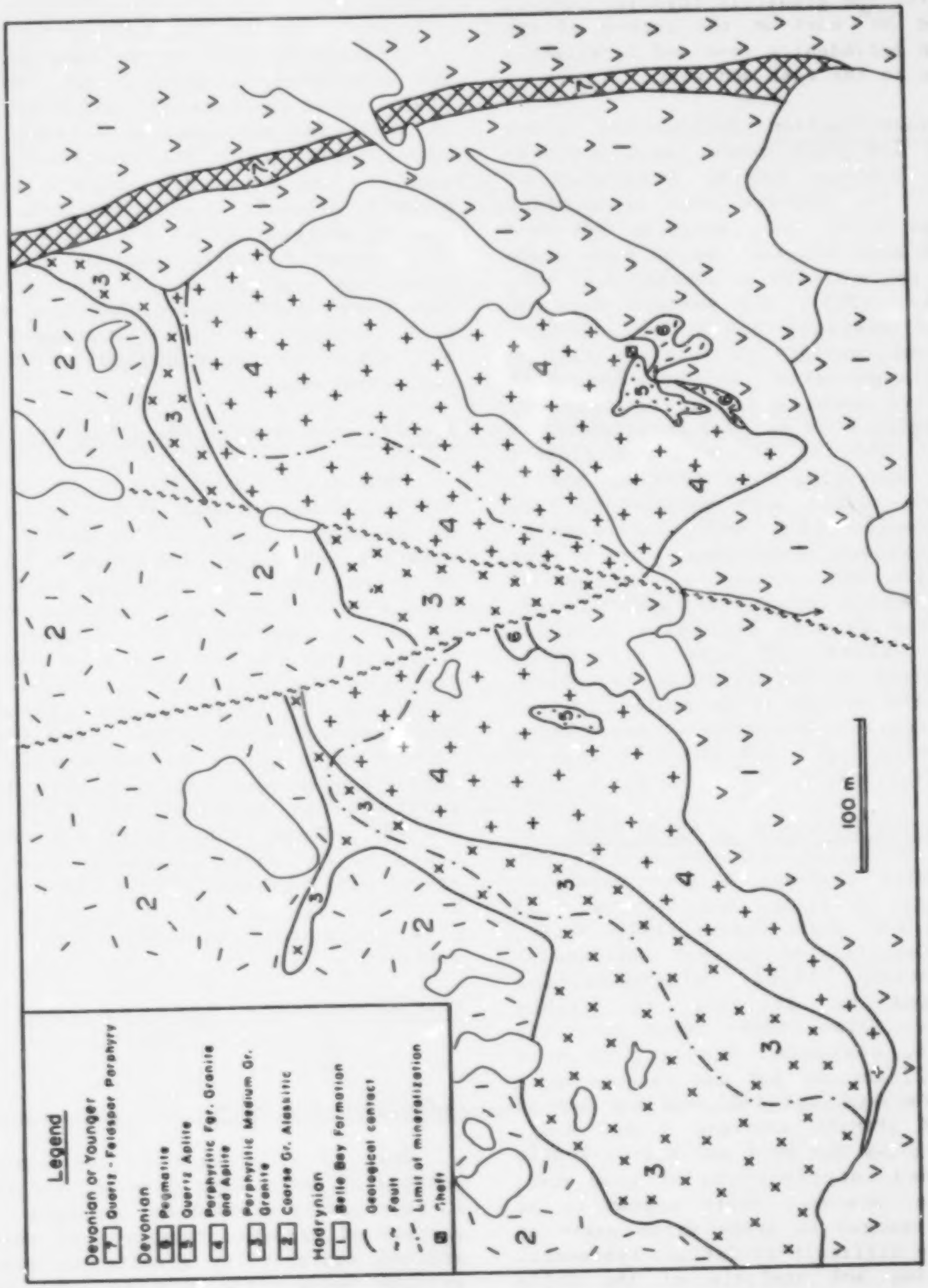

Legend
Devonian or Younger
7 Quartz - Feldspar Porphyry
Devonian
6 Pegmatite
5 Quartz Aplite
4 Porphyritic Fgr. Granite and Aplite
3 Porphyritic Medium Gr. Granite
2 Coarse Gr. Alaskitic
Hadrynian
1 Belle Bay Formation
Geological contact
Fault
Limit of mineralization
Shaft
100 m
1
2
3
4
5
6
7

Figure 17: Geological map of the Wylie Hill molybdenite showing (from Whalen, 1976).

phases represent a sill underlain by alaskite. The granitoid-rhyolite contact dips at 30° east at the centre of the eastern molybdenite zone and is slightly steeper to the east and west.

"*Mineralization:* Molybdenite occurs in two low-grade zones, each approximately 370 by 120 m, separated by faults. The eastern zone on surface averages 0.15% MoS_2 with an enriched surface zone 400 feet by 30 feet close to the contact with an average 0.4% MoS_2 (Fogwill, 1965). The western zone on surface averages 0.08% MoS_2 (Smith, 1936) and consists of fracture filling and disseminated molybdenite with extensive associated pyrite (pyrite: molybdenite = 10:1). Joints oriented at 160°/90° and 135°/60° west are closely spaced, averaging 8 to 25 to the metre. They are coated with molybdenite (2-4 mm), pyrite (2-6 mm), and quartz. Disseminated sulphides are more extensive and consist of nodules of pyrite within which the pyrite forms dendritic growths occupying original quartz sites of the granitoid. Molybdenite occurs either as inclusions within the pyrite or as small (0.5 cm) disseminated rosettes. Associated alteration is limited to minor silicification."

Mineral Potential of Wylie Hill: No tonnage estimates have been made for the Wylie Hill showings despite extensive trenching, drilling, and sinking a 15 foot (4.5 m) shaft (Smith, 1936; Nolan, 1969; Consolidated Toronto Development Corporation, 1958). Mineralization indicated by drilling is highly variable. Nolan (1969) notes generally low MoS_2 contents. However, in hole NLX-69-2, the contact was reached at a down-hole depth of 180' and the top 65 feet of granite averaged 0.345% MoS_2; nearby holes NLX-69-7 and NLX-69-9 also contained intersections of good MoS_2 contents. However, there appear to be abrupt changes in grade which makes an ore body difficult to define. Systematic resampling and analysis of the Wylie Hill trenches (Dickson and Howse, 1982) show grades of less than 0.1% MoS_2 which is lower than that indicated by Smith (1936).

Uranium analyses on the same samples are consistent at about 6 g/t. Whalen (1976) noted the presence of pitchblende in some thin sections, associated with microscopic gold. Tin analyses of 2 samples from Wylie Hill show a slight anomaly. A sample of molybdenite-bearing granite analyzed 30 g/t tin and a sample of apparently barren granite from the same area analyzed 6 g/t tin. Dickson and Howse (1983) showed that the Wylie Hill trenches contain on average 8 g/t Sn with no significantly higher concentrations.

Frank's Pond Showing (from Whalen, 1980)

"The Frank's Pond showing is located 3.5 km north-northwest of the north end of Rencontre Lake, 5 km within the alaskite intrusion. There are a number of lithologically different types of granite in the area which may be mutually gradational, all of which are intrusive into the alaskite. These fine-grained to pegmatitic units are identical to those associated with molybdenite mineralization to the south. Cutting the alaskite are numerous aplite veins and dikes, together with rare quartz veins trending 308°/90° and 072°/90°. These veins, which are rarely over 5 cm wide, locally contain molybdenite flakes (2-3 mm) along their borders. The extent and tenor of mineralization, however, is very sparse."

Unit 15 - Mainly Massive, Coarse Grained, Porphyritic, Biotite Granite

Definition and Extent

Unit 15 is located in the eastern portion of the Ackley Granite. The unit is very poorly exposed and consists of a variety of granites ranging from medium grained equigranular granite to coarse grained porphyritic granite. The area underlain by Unit 15 contains two roof pendants. The small pendant in the

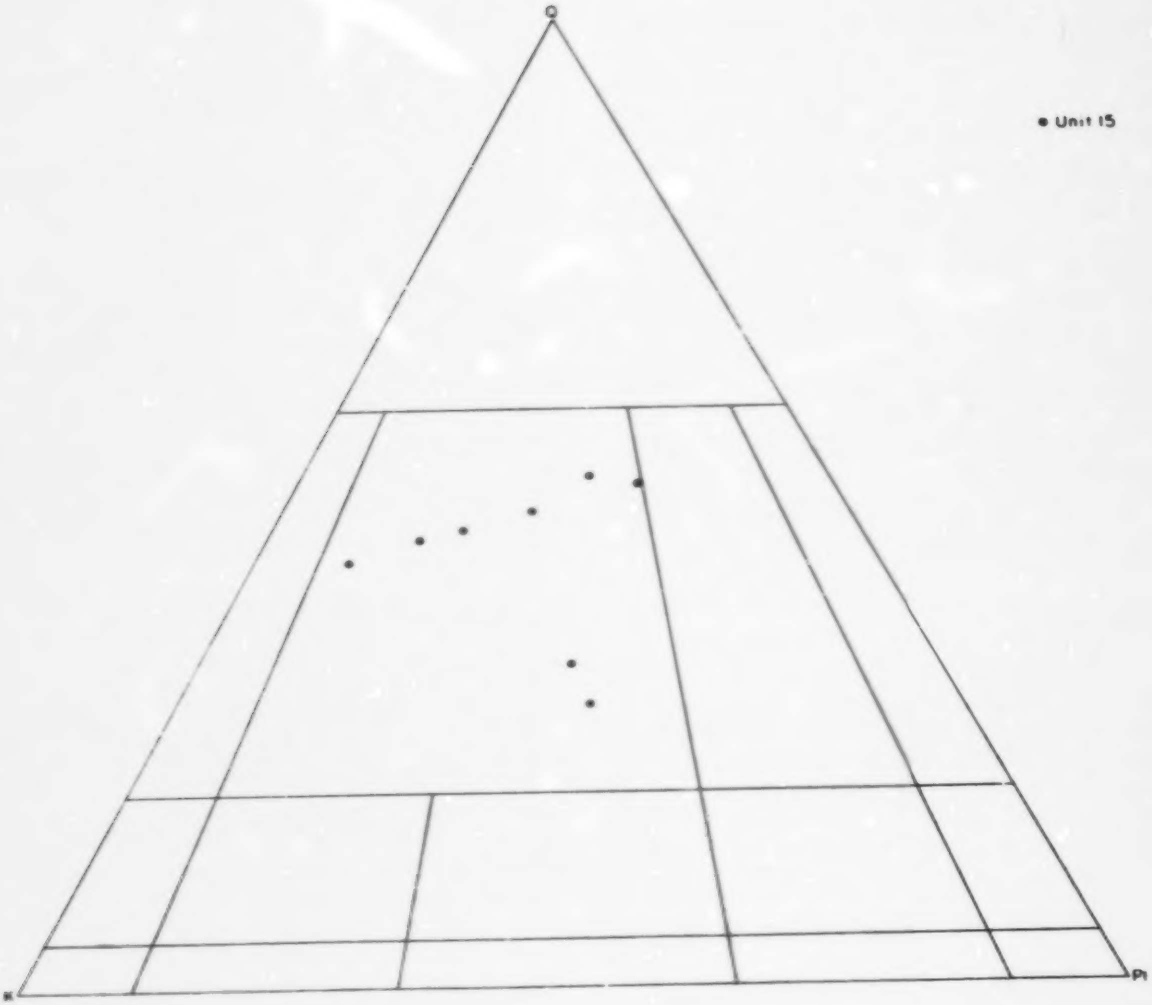


Figure 18: Modal proportions of Q:K:Pl (quartz:K-feldspar:plagioclase) for Unit 15 of the Ackley Granite. Granitoid fields as in Figure 3

western portion of Unit 15 is correlated with the foliated granitoid rocks of the Eastern Meelpaeg and North West Brook Complexes. The eastern pendant contains juxtaposed lithologies typical of the Gander Zone and Avalon Zone. The Gander Zone lithologies are highly mylonitized granites and the Avalon Zone rocks are mainly cleaved tuffs and agglomerates. A granodiorite dike cuts the tuffs near the northern end of the roof pendant. This dike is an intensely mylonitized, medium grained granodiorite which is similar to parts of the Precambrian Swift Current Granite which is exposed 50 km to the southeast. The intense mylonitic deformation of the granitoids suggests that a major fault separates the Gander and Avalon Zone lithologies in this roof pendant. This may be a preserved section of the once continuous Hermitage Bay-Dover fault.

The Dover fault terminates at the contact with Unit 15 at the northeast margin of the unit. There is no evidence in that area that the fault cuts Unit 15.

Lithologies

The dominant lithology of Unit 15 is massive, coarse grained, porphyritic, biotite granite (Figure 18). The rock is generally fresh with minor alteration of biotite to chlorite and plagioclase to sericite and epidote. The essential mineralogy of all the varieties of granite is quartz, orthoclase perthite, plagioclase, and biotite, and may include sphene, magnetite, apatite, zircon and allanite. The porphyritic granite contains phenocrysts of orthoclase perthite, 1 to 4 cm long, and locally plagioclase (Table 11). Albite mantles on the orthoclase phenocrysts are common. The groundmass has a hypidiomorphic-granular texture with anhedral quartz, plagioclase, and orthoclase. Locally, the groundmass has a graphic texture. Quartz displays undulose extinction. Plagioclase shows strong zoning and commonly contains highly sericitized zones. The anorthite content ranges from about An_{25} to An_{15}.

Sphene is common as euhedral crystals up to 1 mm long. Magnetite is commonly associated with biotite. Zircon forms tiny inclusions in biotite. Allanite occurs only rarely.

The medium and coarse grained, equigranular granites are similar to the porphyritic granites, lacking only the perthite phenocrysts.

Aplites and pegmatites are rare. At locality 151, at the northeastern contact of Unit 15 with the Eastern Meelpaeg Complex, a pod of aplite contains miarolitic cavities. This indicates that part of Unit 15 was emplaced at a high level.

No mineralization was found in Unit 15.

TABLE 11: MODAL ANALYSES OF UNIT 15

SAMPLE	112	116	151	153	163	166	168	190
Quartz %	51.7	28.6	44.5	45.8	49.7	48.2	33.2	42.6
K-feldspar	16.9	32.3	37.8	33.8	19.8	27.3	33.2	45.2
Plagioclase	30.5	36.4	12.9	16.4	24.4	21.7	32.2	8.1
Biotite	0.8	2.3	3.8	1.8	5.1	1.4	1.0	2.0
Muscovite	-	-	-	-	-	-	-	-
Hornblende	-	-	-	-	-	-	-	-
Others	-	0.5*	1.0**	2.2***	1.0*	1.4+	0.5^{x}	2.0^{xx}

* Epidote
** Sphene 0.5, Epidote 0.5
*** Opaques 1.8, Epidote 0.4
+ Opaques 0.7, Epidote 0.7
x Opaques
xx Opaques 1.5, Sphene 0.5

GEOCHEMISTRY

Sample Collection and Analysis

The area of the Ackley Granite defined by Bradley (1962), Jenness (1963), Anderson (1965), and Anderson and Williams (1970) was divided up into 988 squares each 4 km^2 in area. Samples were obtained from 587 squares or 59% of the sampling area. It was hoped to use randomly selected sites in all of the map area, but this was possible only in the North West Brook Complex and the southern portion of Unit 14 of the Ackley Granite. Throughout the remainder of the map area outcrop is generally less than 1% and it was fortunate if one outcrop was found anywhere in the square. All granitoid rocks collected were analyzed as well as a few miscellaneous dikes and volcanic rocks. Statistics on sampling results are given in Table 12. Descriptions of analytical methods, precision and accuracy are given in Appendix I. Sample descriptions, major and trace element analyses, and CIPW norms are given in Appendix II.

GEOCHEMISTRY AND PETROGENESIS OF THE NORTH WEST BROOK AND EASTERN MEELPAEG COMPLEXES

Mean Composition

The subdivision of the Eastern Meelpaeg and North West Brook Complexes into three distinct units is supported by mean chemical compositions given in Table 13. Unit 5 which is characterized by its coarse grained, porphyritic texture and high biotite content is more basic than Units 6 and 7. Unit 6, which is medium grained with a lower biotite content than Unit 5, and Unit 7, which is leucocratic and lacks biotite, are more silicic. Units 6 and 7 are particularly depleted in FeO, MgO, CaO,

TABLE 12: SAMPLING STATISTICS

a. 1979 program

Total number of 4 km^2 squares to be sampled.......	988
Total number of 4 km^2 squares sampled.............	578 (59.44%)
Total number of samples collected..................	757
Total number of primary granite samples analysed..	481
Total number of analyses (incl. replicates).......	646
Total number of primary samples N.W.B. Complex....	96
Total number of others (incl. replicates).........	26
Total number of primary samples Ackley Granite....	357
Total number of others (incl. replicates).........	125
Total number of primary samples E.M. Complex......	18
Total number of others (incl. replicates).........	8
Total number of Simmons Brook Batholith...........	2
Total number of various other igneous rocks.......	14
percentage Ackley Granite sampled.................	51.8%
percentage North West Brook sampled...............	95.0%
percentage Eastern Meelpaeg sampled...............	55.0%

b. 1981 program

Total number of samples collected..................	77
Total number of samples analysed..................	27

TABLE 13: MEAN COMPOSITIONS OF UNITS 5, 6, AND 7 OF THE NORTH WEST BROOK AND EASTERN MEELPAEG COMPLEXES

Complex	NWB	NWB	NWB	EMC	EMC	EMC
Unit	5	6	7	5	6	7
n	36	49	11	7	10	1
Oxide wt%						
SiO_2	62.7	71.7	74.6	67.9	70.7	75.0
Al_2O_3	16.0	14.4	13.9	14.7	14.5	13.6
Fe_2O_3	1.46	0.55	0.30	1.35	0.76	0.05
FeO	3.42	1.28	0.37	2.27	1.48	0.26
MgO	2.29	0.59	0.17	1.40	0.82	0.08
CaO	3.13	1.26	0.59	2.20	1.31	0.44
Na_2O	3.03	3.36	4.08	3.17	3.32	4.12
K_2O	4.49	4.74	4.03	4.45	4.51	4.70
TiO_2	0.92	0.29	0.08	0.61	0.36	0.03
MnO	0.11	0.05	0.09	0.09	0.06	0.04
P_2O_5	0.35	0.14	0.17	0.19	0.14	0.14
LOI	1.50	1.07	0.97	1.61	1.26	0.69
Element g/t						
Li	142	62	104	96	78	9
Be	4	5	14	3	4	NA
F	1210	440	439	465	477	192
V	88	21	6	69	34	5
Cr	29	7	6	20	7	5
W	$2(3)^+$	$4(1)^+$	NA	NA	NA	NA
Zn	48	24	10	45	31	2
Ga	17	17	16	16	13	13
Rb	227	220	270	173	208	234
Sr	207	140	31	199	120	49
Y	46	25	17	35	35	7
Zr	243	128	55	212	168	29
Nb	24	19	24	19	23	6
Mo	3	3	3	3	4	3
Sn	NA	$1.0(2)^+$	NA	1(1)+	NA	NA
Ba	728	416	77	538	468	73
La	44	24	14	36	26	5
Ce	131	90	75	91	87	72
Pb	25	37	27	28	29	36
Th	18	17	13	16	16	3
U NA*	3.2	3.2	2.6	2.3	3.1	1.4
Ratios						
Rb/Sr	3.25	2.99	17.04	1.18	3.12	4.78
Ba/Rb	3.52	2.47	0.03	3.09	2.58	0.31
Ba/Sr	3.67	3.35	1.79	2.91	5.30	1.49
K/Rb	170	194	126	216	195	166

---

(2) + : number of analyses in parentheses

* : U determined by neutron activation

NA : not analyzed for this element

TiO_2, Sr and Ba compared to Unit 5. Unit 5, however, contains anomalously high K_2O, Li, F, Rb, and Th for the relatively low mean SiO_2 content.

Variation diagrams

Variation diagrams of selected elements against Thornton-Tuttle Differentation Index (TTDI) are given in Figures 19 to 29 for the North West Brook Complex. The plot of SiO_2 against TTDI shows that there is the expected increase in SiO_2 with TTDI. Unit 5, at the same TTDI (approximately 77%), however, is approximately 4% lower in SiO_2 than Unit 6 which suggests that Units 5 and 6 form separate differentiation sequences (Figure 19). This is further emphasized by K_2O which is markedly higher in Unit 5 than Unit 6 at the same TTDI (Figure 20). Unit 5 also contains higher Li than Unit 6 (Figure 22) whereas U, Th, and Rb values are similar irrespective of TTDI (Figure 23, 24 and 25). Rubidium in Unit 5 is relatively constant with increasing TTDI whereas in Unit 6 it shows a gradual increase, again suggesting that the two units are not related by fractionation. The high F and Li concentrations in Unit 5 are probably related to the high biotite content (Figure 26).

Unit 7 is on average the most differentiated of the three components of the North West Brook Complex. Soda (Figure 21) is considerably higher and K_2O lower in Unit 7 compared to Unit 6 at the same TTDI; the alkalis do not follow the trends shown in Unit 6. The high differentiation index and SiO_2 content of Unit 7 is reflected in particularly high Li values and low Sr and Ba contents. Rubidium is not particularly enriched in Unit 7 but the Rb/Sr ratio is high (17.04) and K/Rb ratio is low (approximately 126) (see Table 13). An unusual feature of Unit 6 is the relatively high MnO content of some of the samples (see Figure 29). This may be related to the occurrence of tourmaline which may contain a signficant amount of Mn.

The Eastern Meelpaeg Complex generally shows chemical variations similar to the North West Brook Complex. Unit 5, however, shows a much wider range in differentiation index and SiO_2 content and therefore higher mean SiO_2, and hence may include more than one coarse grained, porphyritic, biotite granite intrusion (Figure 30). There is clearly a bimodal distribution of TTDI for Unit 5 with a gap between TTDI 70 and 88. The sample with the highest SiO_2 contents (220194) is mylonitized and silicified, however, which accounts for the abnormally high SiO_2 content and thus lower than expected contents of the other oxides.

Petrogenesis

Plots of A:F:M [$(Na_2O + K_2O)$:(total Fe as FeO):(MgO)], shown in Figure 31, display the slightly different trends for Unit 5 of the North West Brook Complex compared to Units 6 and 7. Unit 5 is more MgO-rich than Units 6 and 7 and is clearly separated from Unit 7 which is relatively depleted in FeO and MgO. Unit 7 shows a strong concentration near the $Na_2O + K_2O$ apex. Unit 5 and Unit 6 of the North West Brook Complex define parts of two calc-alkaline trends and fall within the field of granitoids of part of the Peruvian Coastal Batholith (Atherton *et al.*, 1979).

The magmas of Units 5, 6, and 7 were probably rich in water. This is indicated by the presence of abundant pegmatites and hydrous phases such as biotite and muscovite. The absence of kyanite in the screens of pelitic metasediment provides an upper pressure limit for crystallization. Colman-Sadd (1976) notes the conversion of andalusite to sillimanite in the gneissic rocks adjacent to garnetiferous, leucocratic granitoids and this provides a lower P-T boundary. Similarly the presence of primary muscovite in Units 6 and 7 provides an approximate upper temperature limit. These conditions are shown in Figure 32.

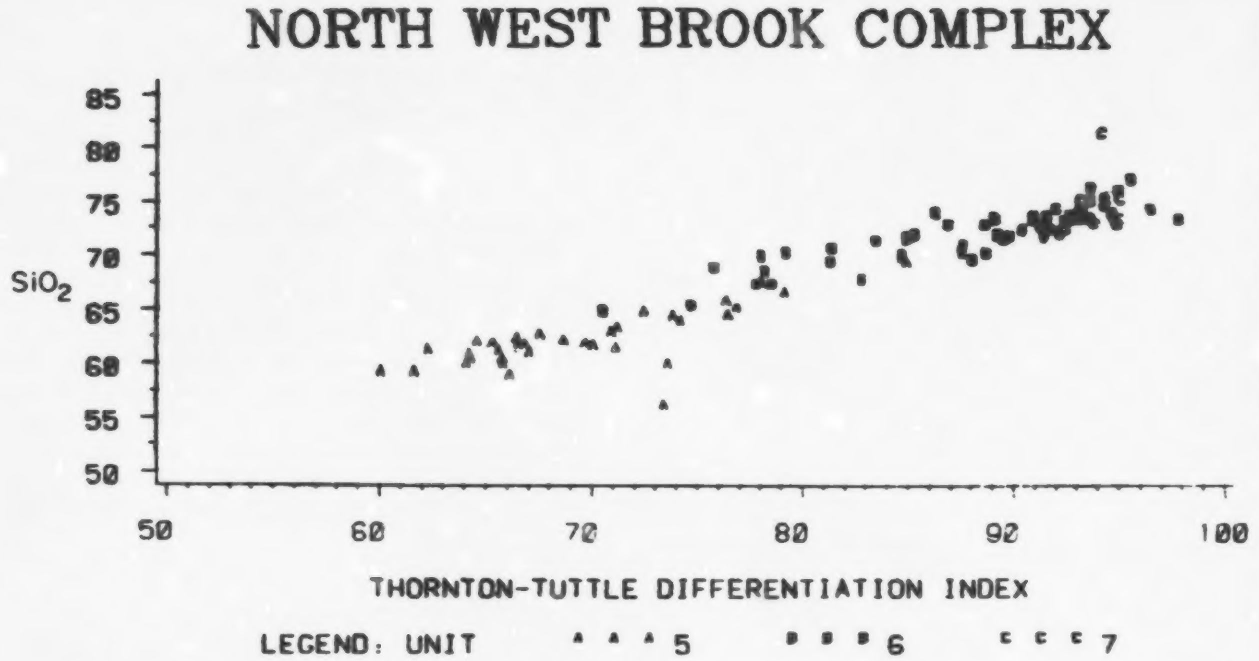


Figure 19: *SiO_2 vs. Thornton-Tuttle Differentiation Index (both weight %) for Units 5, 6 and 7 of the North West Brook Complex.*

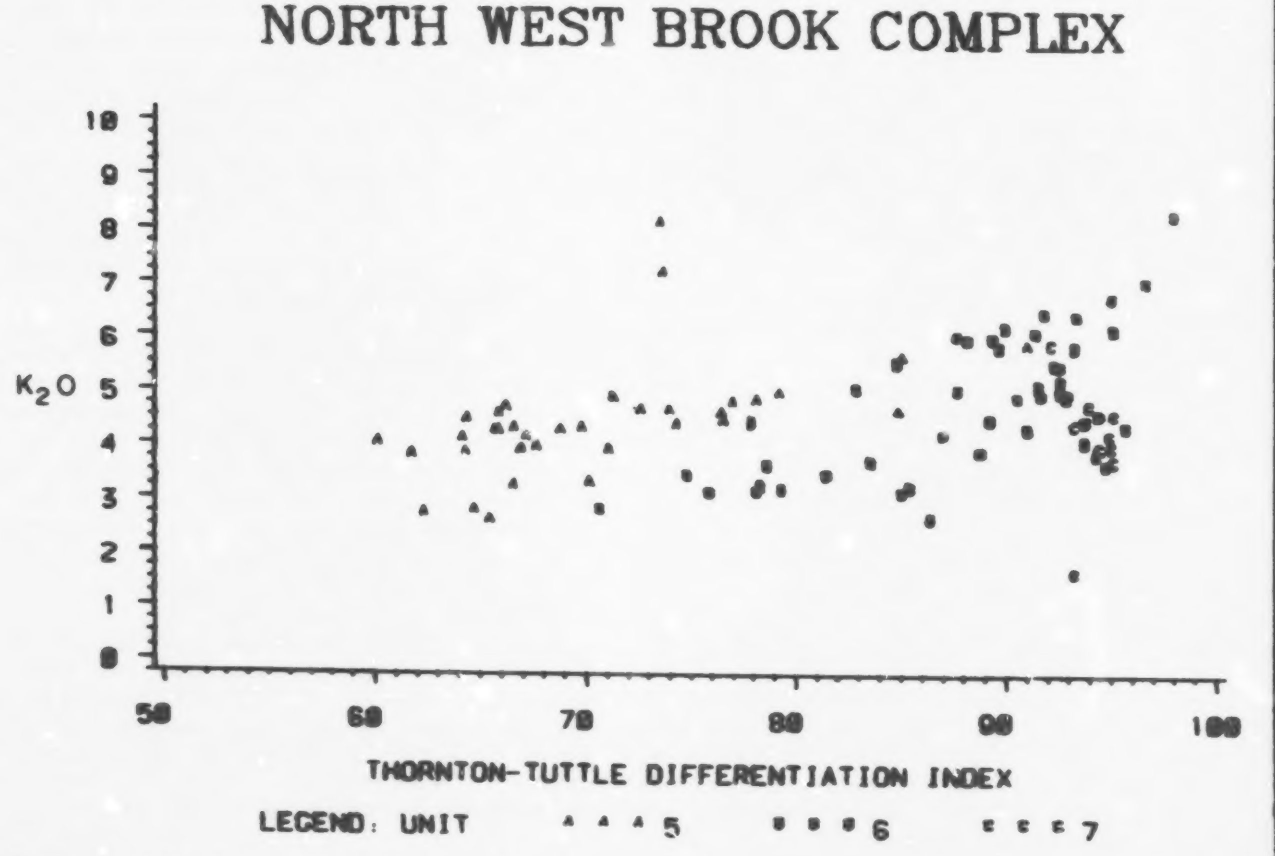


Figure 20: *K_2O vs. Thornton-Tuttle Differentiation Index (both weight %) for Units 5, 6 and 7 of the North West Brook Complex.*

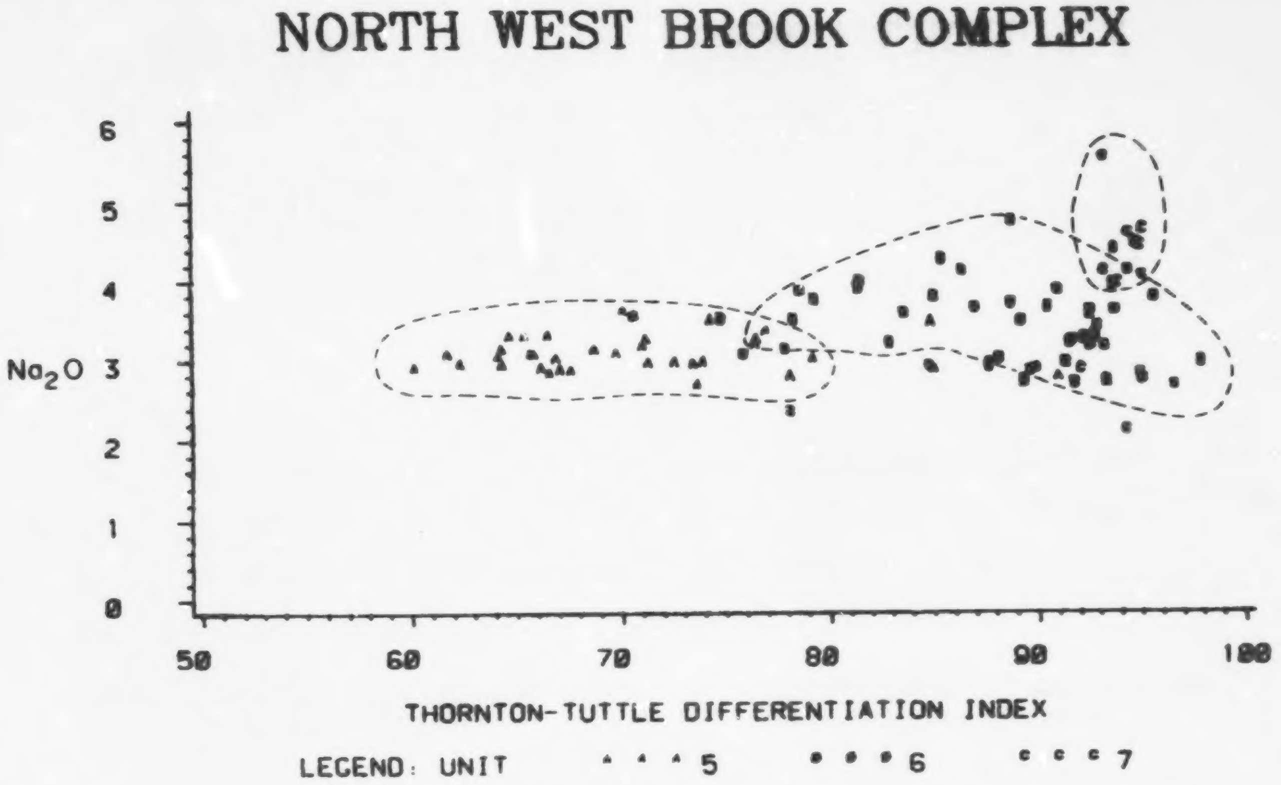


Figure 21: Na_2O vs. Thornton-Tuttle Differentiation Index (both weight %) for Units 5, 6 and 7 of the North West Brook Complex.

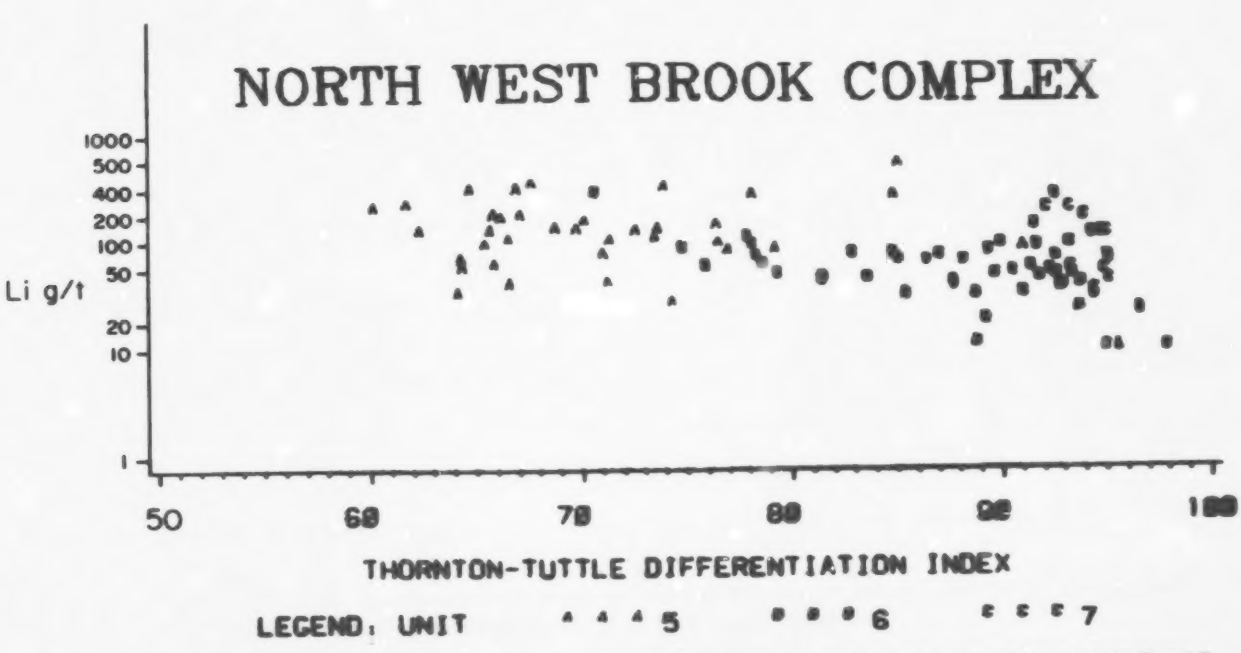


Figure 22: Lithium (g/t, on logarithmic scale) vs. Thornton-Tuttle Differentiation Index (weight %) for Units 5, 6 and 7 of the North West Brook Complex.

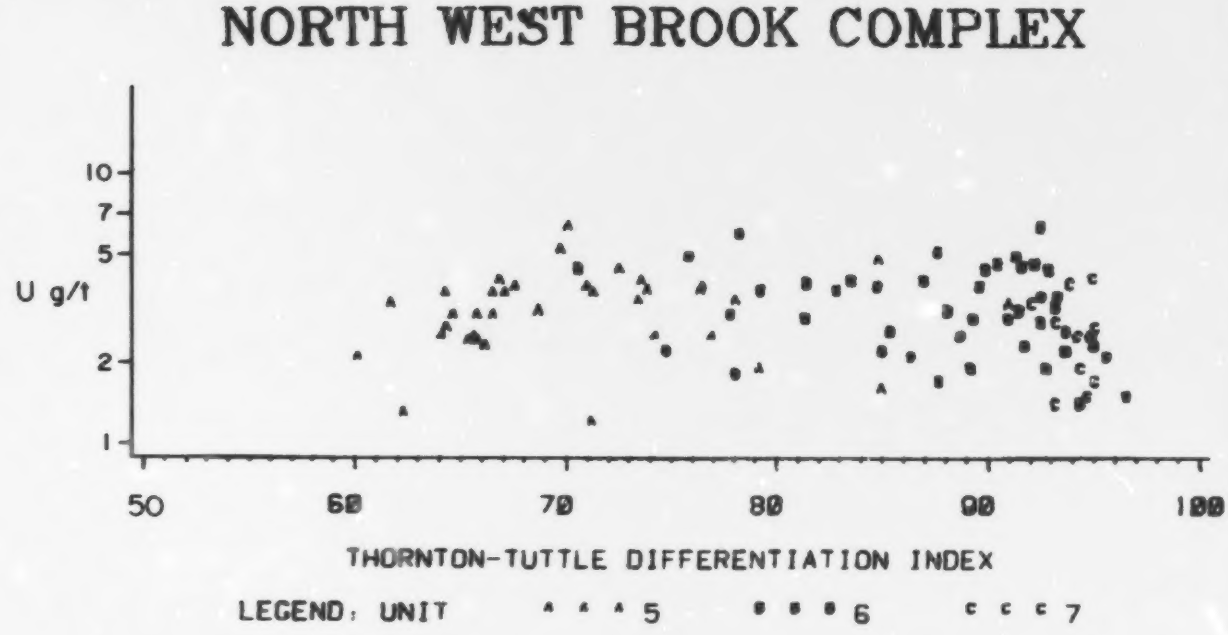


Figure 23: Uranium (g/t, on logarithmic scale) vs. Thornton-Tuttle Differentiation Index (weight %) for Units 5, 6 and 7 of the North West Brook Complex.

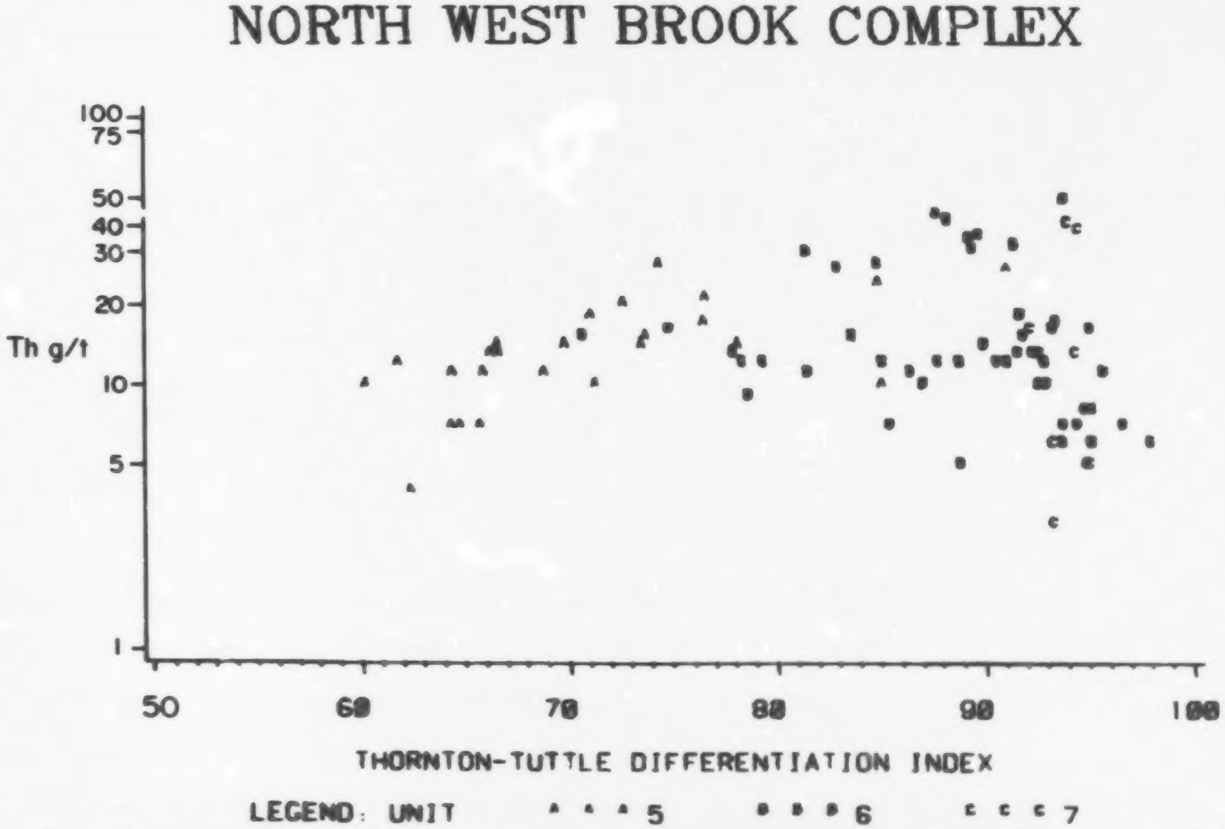


Figure 24: Thorium (g/t, on logarithmic scale) vs. Thornton-Tuttle Differentiation Index (weight %) for Units 5, 6 and 7 of the North West Brook Complex.

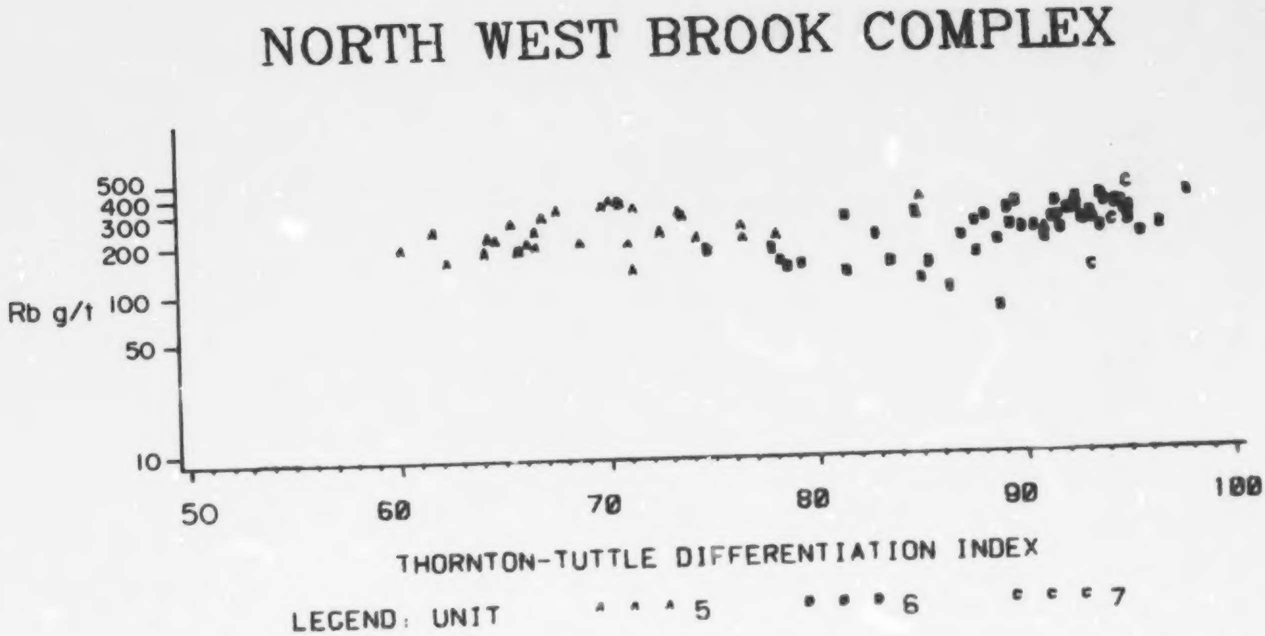


Figure 25: *Rubidium (g/t, on logarithmic scale) vs. Thornton-Tuttle Differentiation Index (weight %) for Units 5, 6 and 7 of the North West Brook Complex.*

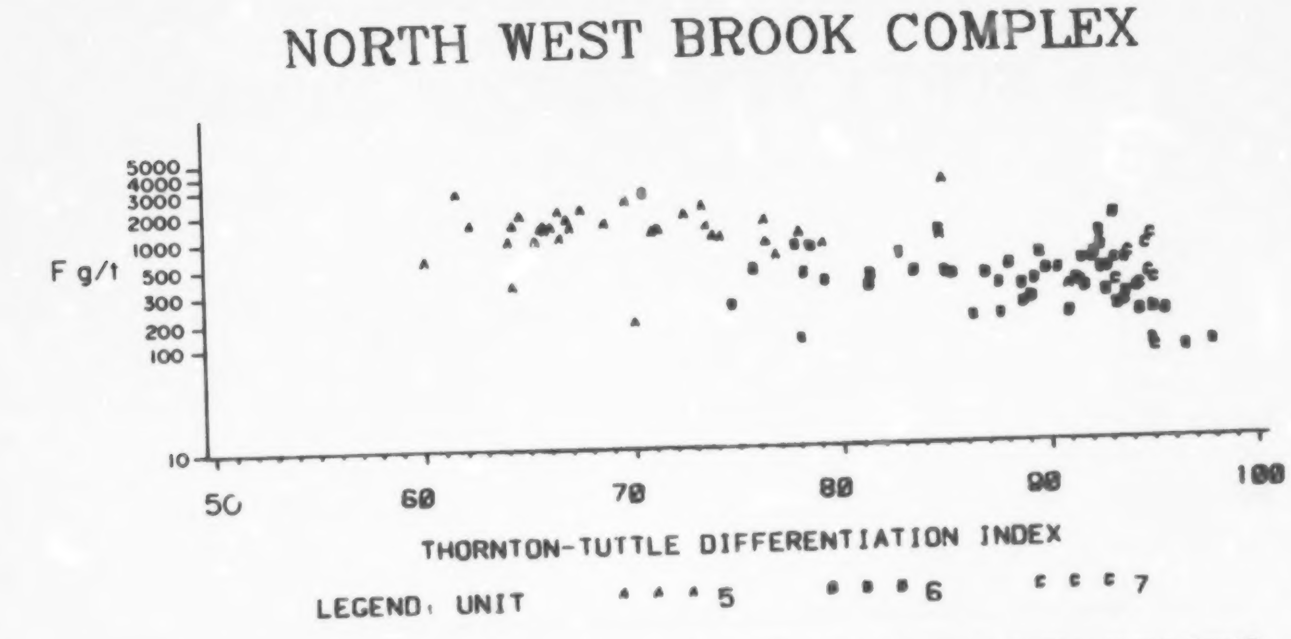


Figure 26: *Fluorine (g/t, on logarithmic scale) vs. Thornton-Tuttle Differentiation Index (weight %) for Units 5, 6 and 7 of the North West Brook Complex.*

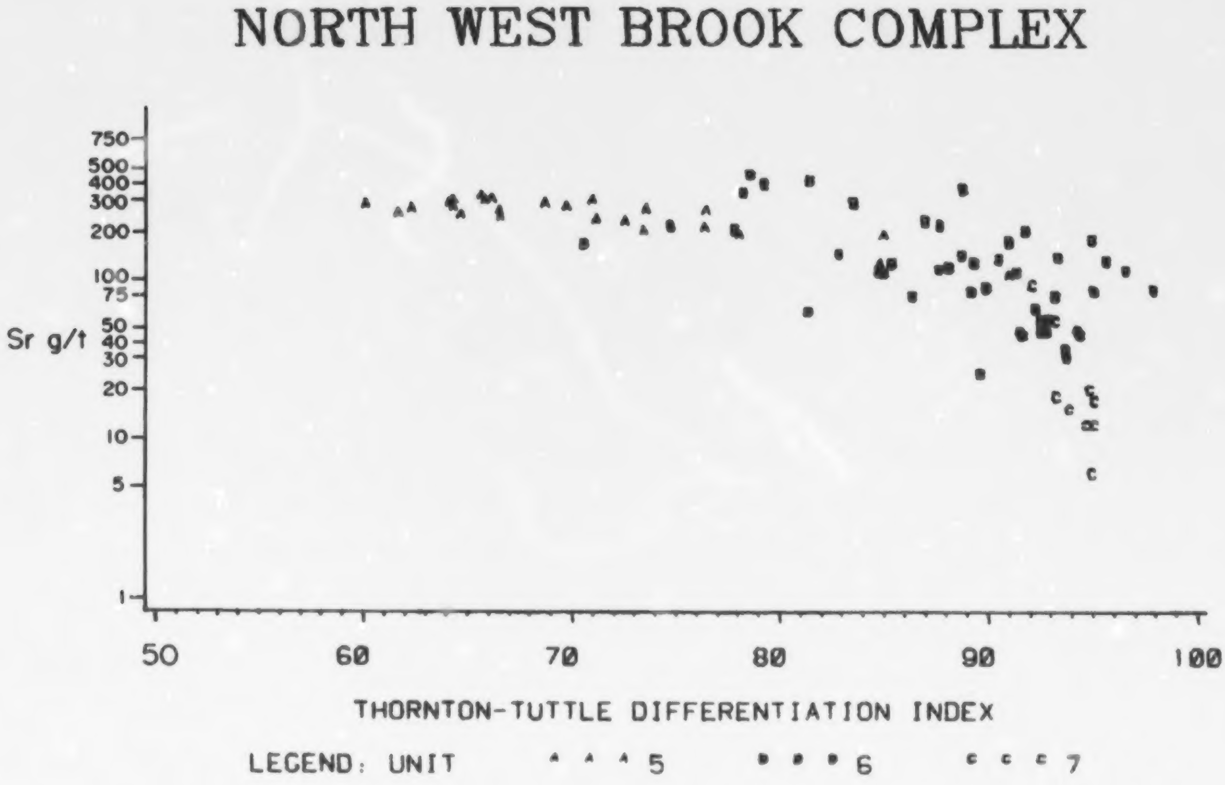


Figure 27: *Strontium (g/t, on logarithmic scale) vs. Thornton-Tuttle Differentiation Index (weight %) for Units 5, 6 and 7 of the North West Brook Complex.*

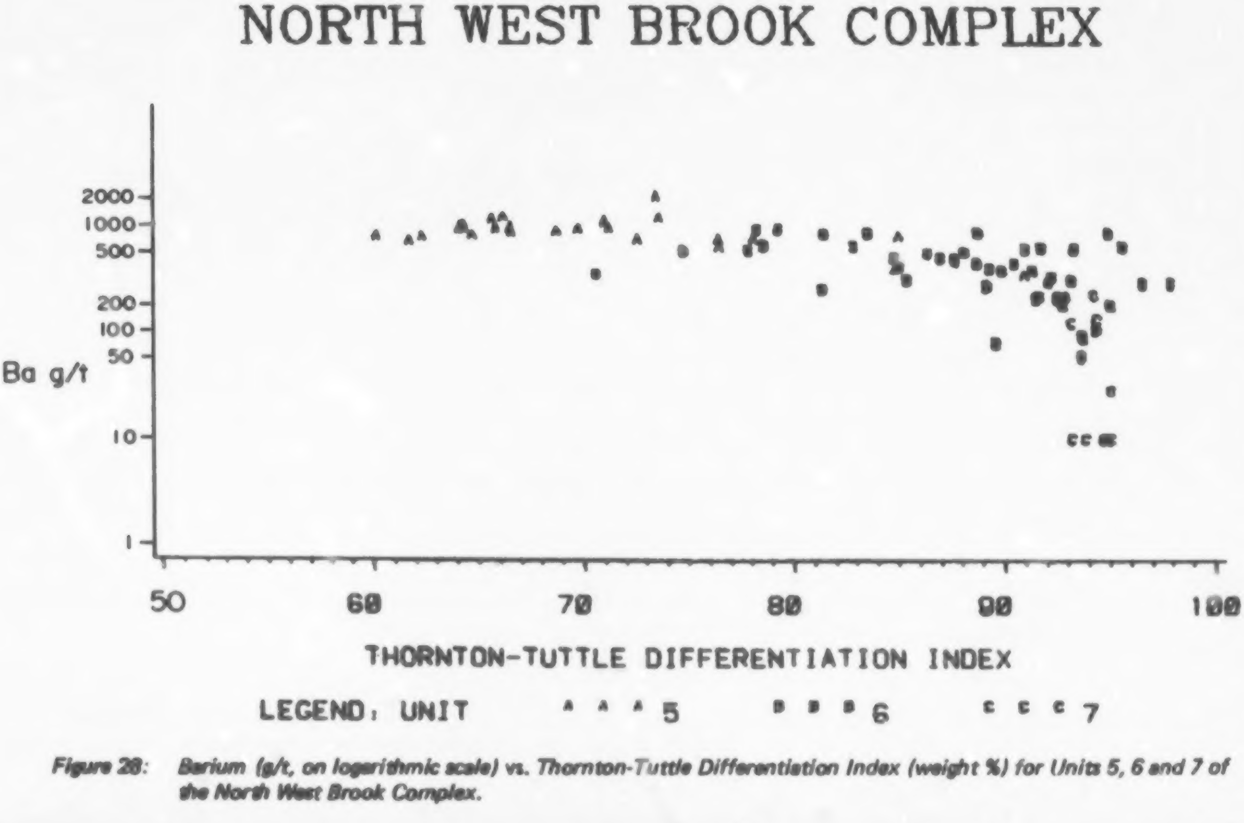


Figure 28: *Barium (g/t, on logarithmic scale) vs. Thornton-Tuttle Differentiation Index (weight %) for Units 5, 6 and 7 of the North West Brook Complex.*

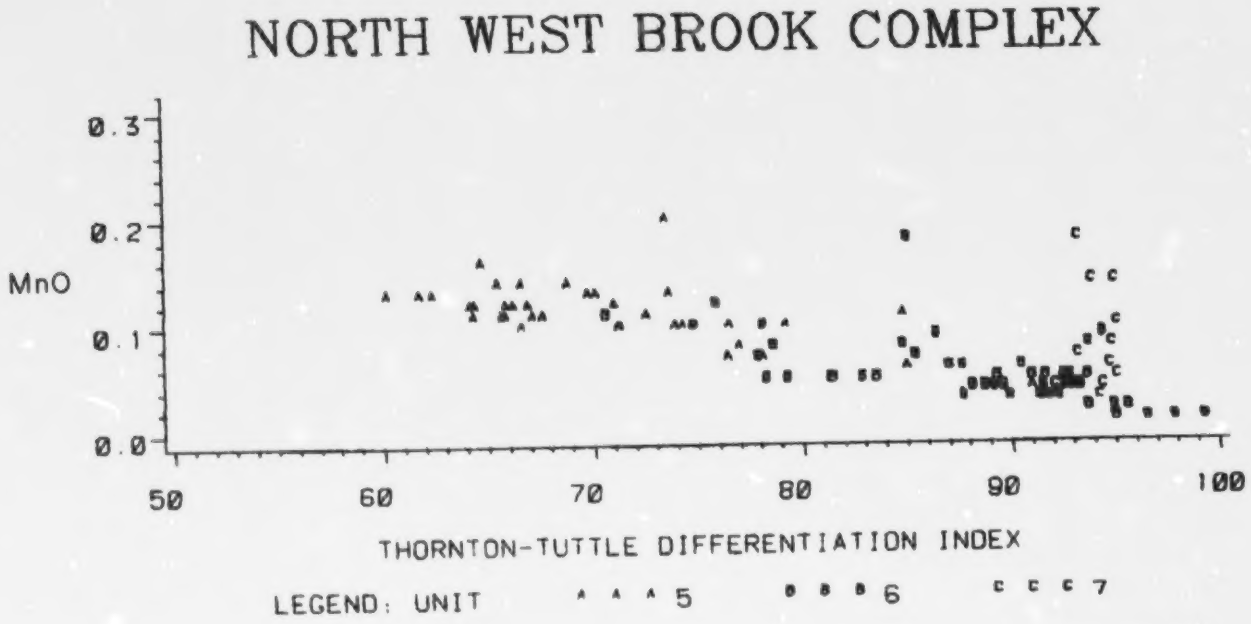


Figure 29: Manganese vs. Thornton-Tuttle Differentiation Index (both weight %) for Units 5, 6 and 7 of the North West Brook (NWB) and Eastern Meelpaeg (EMC) Complexes.

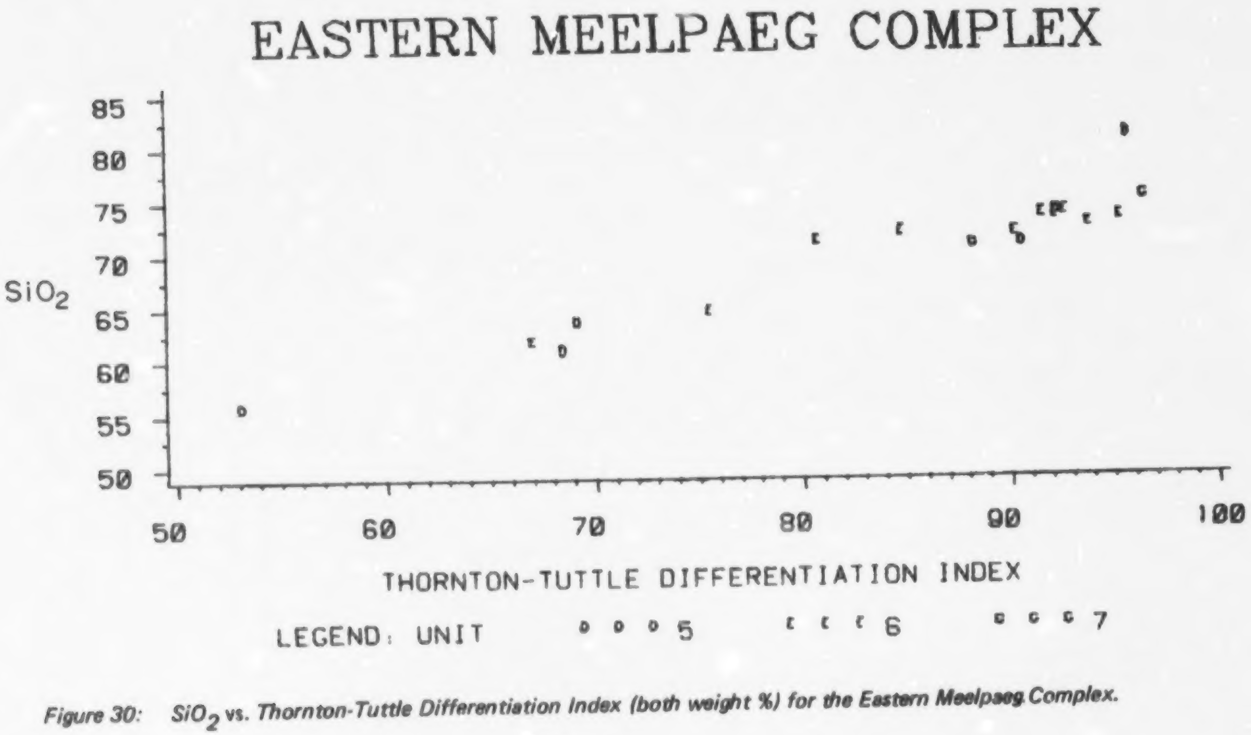


Figure 30: SiO_2 vs. Thornton-Tuttle Differentiation Index (both weight %) for the Eastern Meelpaeg Complex.

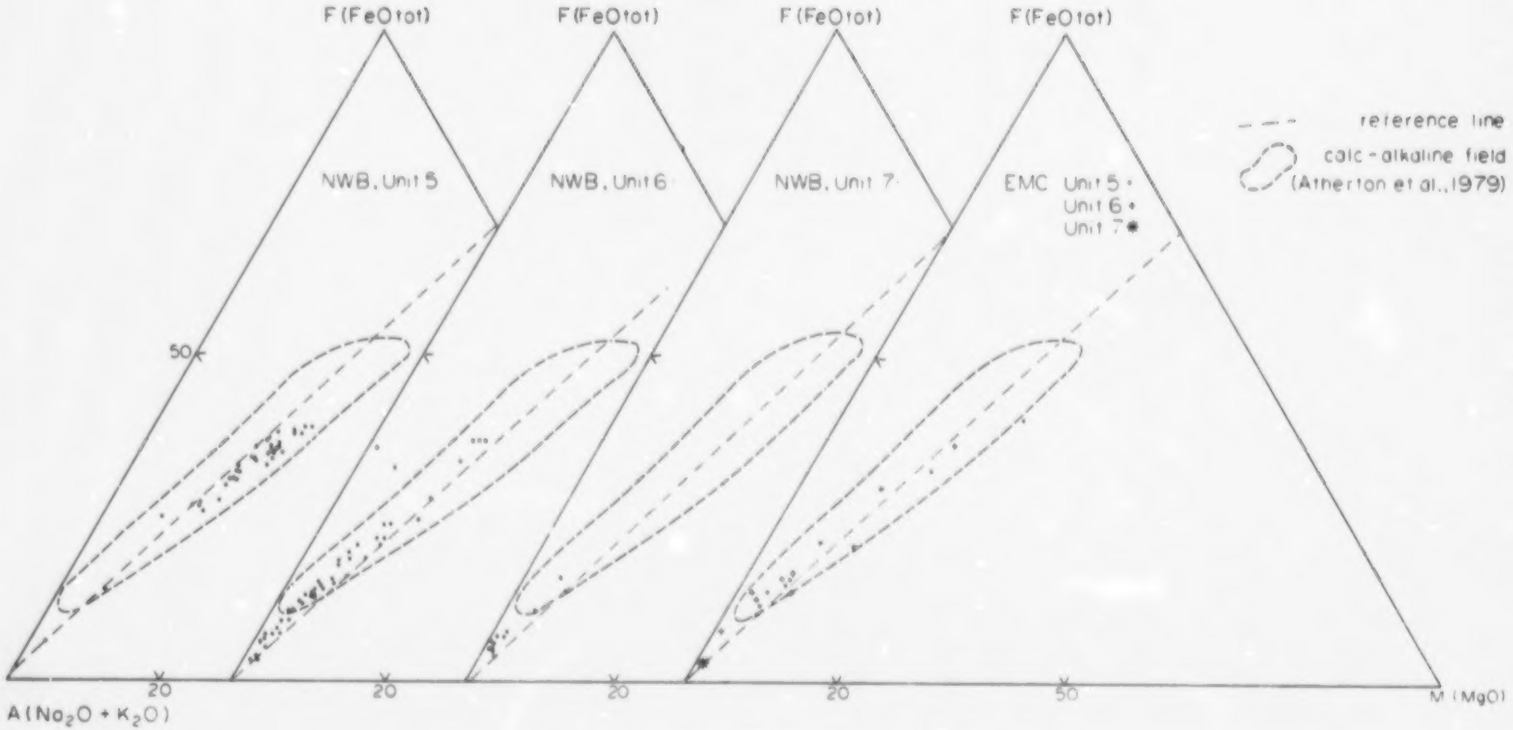


Figure 31: AFM diagrams ($Na_2O + K_2O$: total iron as FeO : MgO in weight %) for Units 5, 6 and 7 of the North West Brook (NWB) and Eastern Meelpaeg (EMC) Complexes. Dashed reference line is estimated best fit based on total data for the North West Brook Complex.

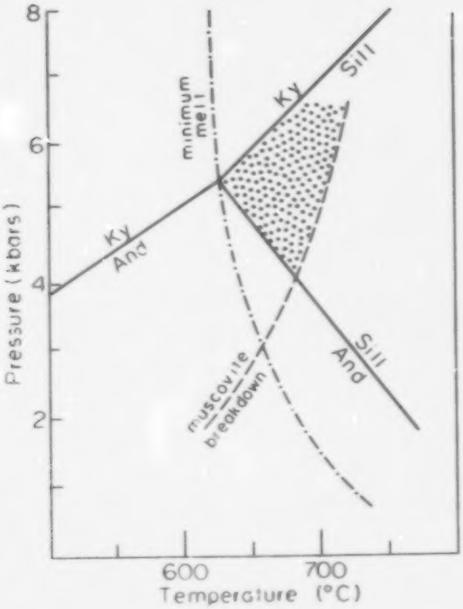


Figure 32: Estimation of pressure - temperature limits of formation of Units 6 and 7 (stippled) of the North West Brook and Eastern Meelpaeg Complexes. Modified from Pickerill et al. *(1978).*

The leucocratic granitoids (Unit 7) are probably late differentiates of Unit 6. This is suggested by field and geochemical data. The leucogranites are most abundant within the area underlain by Unit 6. This situation has been noted in other areas within the Gander Zone, such as the Ragged Harbour area (Currie and Pajari, 1977), where a gradation was also noted from marginal garnet-muscovite granite to biotite granite and granodiorite within the Aspen Cove Pluton.

Variation diagrams, *e.g.* Harker plots, AFM, and Q:Ab:Or, also suggest that the Unit 7 granites are late stage differentiates of Unit 6. In the AFM diagrams (Figure 31) analyses of Unit 7 tend to concentrate nearer the Na + K apex and at the Na + K end of the trend for Unit 6). Similarly in the Q:Ab:Or diagram (Figure 33) the leucogranites lie nearer the ternary eutectic and on the trend defined by Unit 6.

The P-T conditions indicated for the formation of Units 6 and 7 are obviously to be found within continental crust. The criteria defined by Chappell and White (1974) for determining source rock should therefore indicate a "sedimentary" source rock. A frequency plot of the I-S ratio (*i.e.* $Al_2O_3/(K_2O+Na_2O+CaO)$ in molecular weight %) (see Figure 34) indicates that Unit 7 and the muscovite-bearing portion of Unit 6 straddle the boundary. Unit 5 falls mainly within the I-type field. The Na_2O values for Units 6 and 7 are mainly higher than the normal limit of 3.2% Na_2O for "S-type" granitoids, however, whereas Unit 5 is below the limit for I-type granitoids (see Figure 21). Normative corundum values greater than 1.1% are also considered characteristic of S-type granites. Virtually all samples from the North West Brook and Eastern Meelpaeg Complexes are corundum normative and the majority of samples in Units 5 and 6 have values greater than 1.1% (Figure 35). All of Unit 7 has normative corundum values greater than 1.1%.

Unit 5 of the North West Brook Complex is enriched in the incompatible elements K_2O, Rb, Li and U. This suggests that Unit 5 formed by partial melting of continental crust. The low mean SiO_2 content of Unit 5 indicates that the magma was depleted in SiO_2. This would occur if the magma were fractionated at pressures probably greater than 5 kbars. The absence of muscovite in Unit 5, which is as corundum-normative as Unit 6 and 7, is probably related to its high content of MgO and FeO which, with excess Al_2O_3, would be incorporated by biotite.

Geochemical indicators of the mineral potential of the Eastern Meelpaeg and North West Brook Complexes

Trace element analyses for economic elements indicate only a few samples which are anomalous in more than one element. There are several isolated

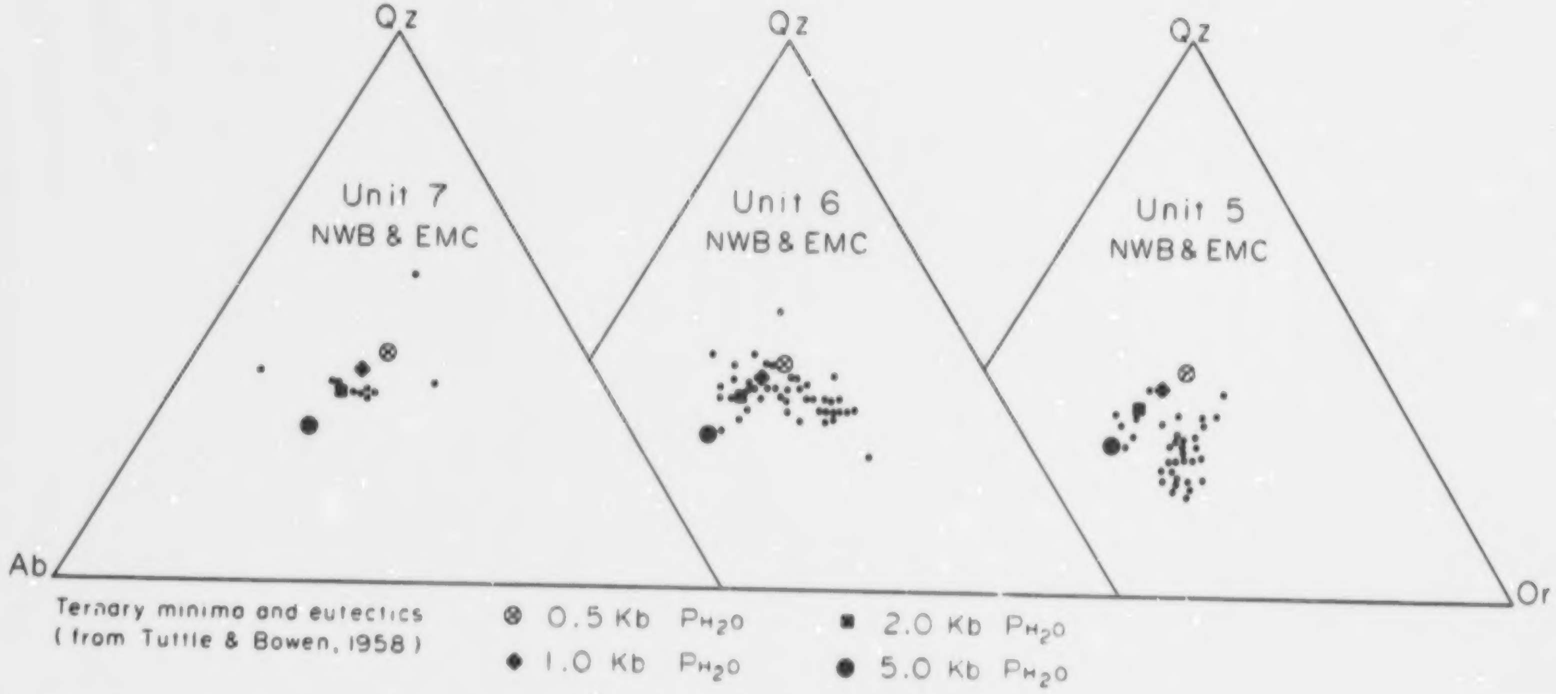


Figure 33: Normative proportions of Qz:Ab:Or (quartz:albite:orthoclase) for Units 5, 6 and 7 of the North West Brook (NWB) and Eastern Meelpaeg (EMC) Complexes.

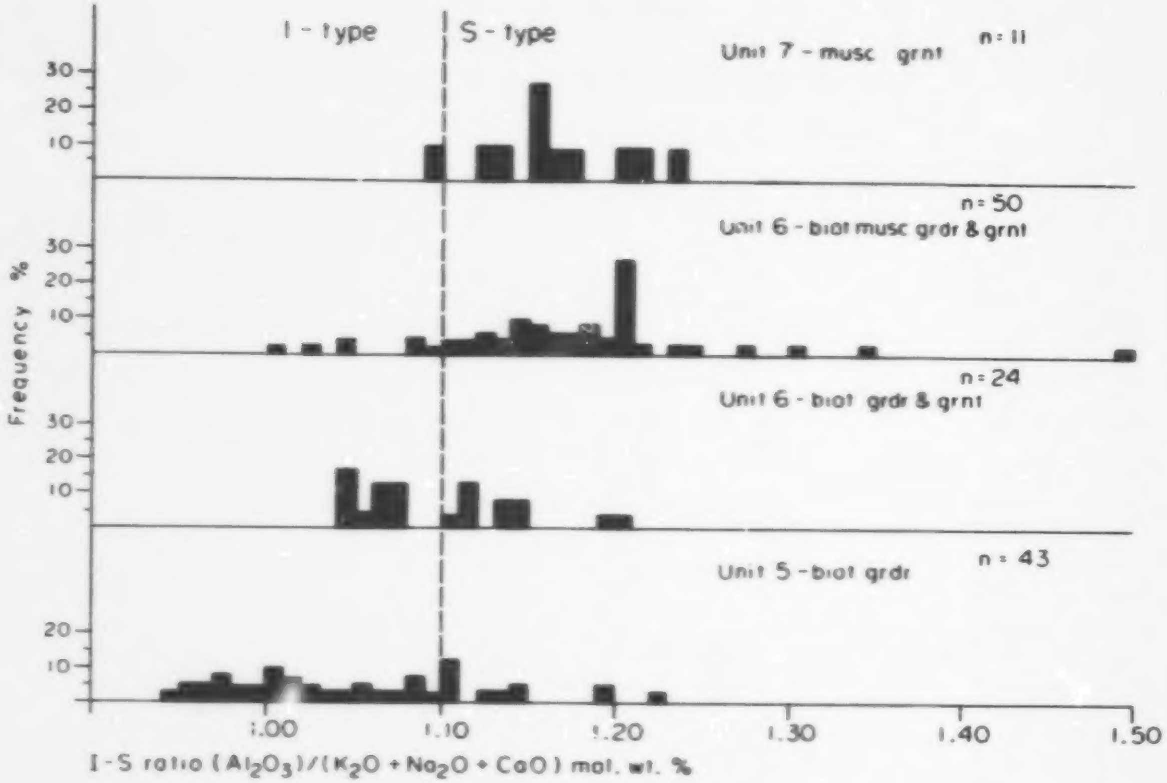


Figure 34: Frequency of I-S ratios for Units 5, 6 and 7 of the North West Brook and Eastern Meelpaeg Complexes. Note: Unit 6 is divided into muscovite-free and muscovite-bearing units. n = number of analyses.

anomalous values for Cu, Mo, Pb, Zn and F. The highest copper values obtained are 41 and 42 g/t (in samples 220481, and replicate analysis 220784). This sample also contains the highest Pb value in the entire map area with 156 g/t. The host rock is a very coarse grained to pegmatitic muscovite-biotite granite.

Sample 220621 is unusual in that it contains over 8% K_2O, with a very small proportion of modal quartz and is composed mainly of orthoclase perthite and plagioclase. CIPW norm calculations show that the sample is olivine-normative. This, however, is caused by the low SiO_2 content of the rock, which is insufficient to produce all the feldspar. The proportion of biotite in the rock is about 5% which, when recalculated in the norm as hypersthene, will use up a sizable proportion of the available SiO_2. The analysis also shows high Zn and Ba. The Zn could be contained in the biotite. The high Ba is probably related to the high K_2O and potash feldspar content of the rock.

The Eastern Meelpaeg and North West Brook Complexes appear to have little economic potential based upon whole rock geochemistry and lake sediment geochemistry (Butler and Davenport, 1978a, 1979b). Minor beryl and tourmaline are the only mineral occurrences found in the area. Most pegmatites are barren.

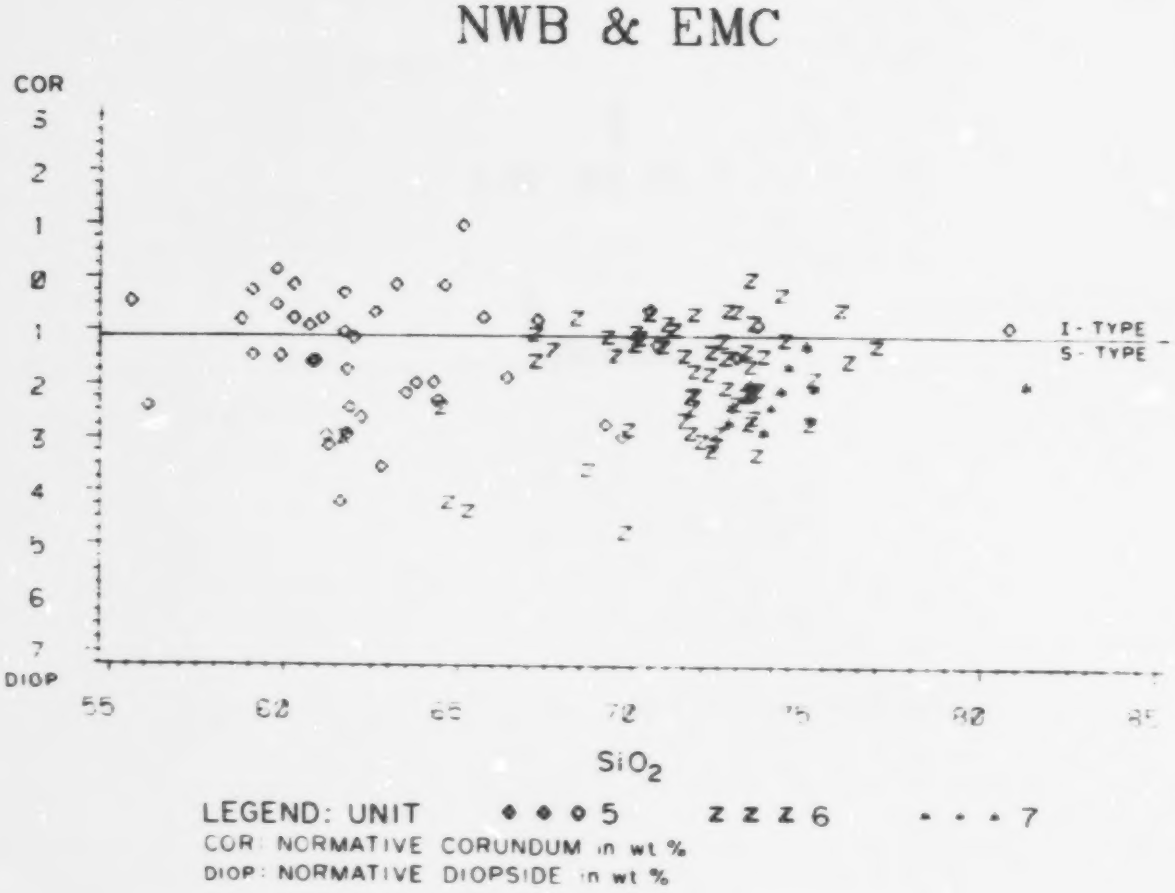


Figure 35: Normative diopside and corundum vs. SiO_2 (all in weight %) for the North West Brooks(NWB) and

GEOCHEMISTRY OF THE ACKLEY GRANITE

Mean Composition of Units 9 to 15

The table of mean compositions (Table 14) for the units of the Ackley Granite indicates the Ackley Granite can be divided into two major components. The four northern units, *i.e.* Units 9, 10, 11 and 12, have a significantly lower mean SiO_2 content than the three southern units, *i.e.* Units 13, 14, and 15. The variation in mean SiO_2 in each unit generally corresponds with changes in the other major elements, so that elements which commonly decrease with increasing differentiation or SiO_2 content, *i.e.* Al_2O_3, FeO, Fe_2O_3, CaO, MgO, TiO_2, MnO, and P_2O_5, become strongly depleted, and those which increase with increasing SiO_2 or differentiation generally increase, *e.g.* Na_2O and K_2O. It is notable, however, that K_2O is generally high throughout the Ackley Granite and is not highest in the units with the highest mean SiO_2. This is probably related to the high proportion of biotite and alkali feldspar in the northern units. Apart from Unit 11, mean Na_2O content is significantly lower in the northern units, than in the southern units.

Mean trace element values generally follow the normal patterns expected with increasing silica. Thus, V, Zn, Sr, and

TABLE 14: MEAN COMPOSITIONS OF UNITS 9-15 OF THE ACKLEY GRANITE

Unit	9	10	11	12	13	14	14A west	14A east	15	11B
n	29	22	48	15	10	142	50	8	21	19
Oxide %										
SiO_2	68.4	68.9	72.2	70.6	74.6	75.7	75.3	76.9	75.1	72.6
Al_2O_3	14.5	14.4	13.9	14.1	12.8	12.5	12.7	12.0	12.9	14.1
Fe_2O_3	0.95	0.84	0.60	0.68	0.47	0.39	0.35	0.30	0.50	0.45
FeO	2.09	1.81	1.10	1.62	0.91	0.87	0.93	0.62	0.67	1.0
MgO	1.31	1.15	0.60	0.86	0.29	0.19	0.17	0.11	0.32	0.51
CaO	2.10	1.92	1.16	1.53	0.77	0.50	0.51	0.32	0.61	1.12
Na_2O	3.17	3.09	3.59	3.20	3.34	3.59	3.77	3.51	3.57	3.73
K_2O	4.90	5.02	4.66	5.21	5.21	4.97	4.91	4.99	5.06	4.63
TiO_2	0.57	0.46	0.32	0.45	0.26	0.19	0.19	0.11	0.24	0.26
MnO	0.08	0.06	0.06	0.06	0.04	0.04	0.04	0.03	0.04	0.06
P_2O_5	0.17	0.12	0.09	0.11	0.05	0.03	0.03	0.01	0.04	0.08
L.O.I.	1.18	1.32	1.01	0.96	0.68	0.71	0.71	0.77	0.76	0.97
Element g/t										
Li	37	38	62	51	37	43	30	87	23	80
Be	4	N.D.	7	5	5	6	7	8	3	7
F	769	498	589	707	675	916	551	2162	328	556
V	56	52	26	41	11	11	10	5	9	20
Cr	4	16	6	9	5	6	6	5	5	5
Ni	44	41	33	55	46	60	54	106	26	27
Cu	4	5	3	2	3	2	2	2	2	2.3
Zn	31	22	18	25	10	15	20	12	12	18
Ga	15	15	17	18	16	18	18	21	13	17
Rb	231	217	229	295	255	323	262	560	207	223
Sr	167	197	257	119	93	54	48	11	93	305
Y	44	29	31	45	54	73	76	99	32	21
Zr	185	159	133	184	153	166	169	154	141	109
Nb	23	16	22	28	31	47	44	76	22	18
Mo	3	4	4	3	5	4	4	5	4	4
Sn	1.3	1.2	1.1	1.4	1.6	4.0	2.4	3.3	1.1	1.1
Ba	503	521	485	384	293	185	180	57	295	584
La	39	34	31	39	39	45	42	34	40	22
Ce	129	103	120	172	212	161	147	272	106	93
Pb	29	32	28	36	24	27	26	35	25	29
Th	28	22	21	30	28	39	32	66	23	14
U (NA)	4.4	3.3	4.3	5.0	4.4	7.2	6.4	14.5	3.5	4.7
Ratios										
Rb/Sr	2.39	1.62	1.36	3.14	6.03	21.02	26.60	59.5	2.86	
Ba/Rb	2.49	2.70	2.29	1.59	1.38	0.79	0.90	0.11	1.65	
Ba/Sr	3.00	2.74	2.12	3.24	3.75	3.46	3.57	5.23	3.66	
K/Rb	182	195	174	158	180	143	170	74.3	212	

Ba show a strong depletion and Ga, Rb, Nb, Mo, Sn, Ce, Th, and U generally show a steady enrichment with increasing SiO_2. The trends shown by the mean values of the other elements are less well defined. Subunit 14a (southwest of Gisborne Lake) however, shows a strong enrichment in some of the elements which generally have average concentrations in the other units, *e.g.* F, Li, and Y. The increase in F and Li is particularly interesting as high values for F and Li are considered a guide to potential mineralized areas.

Silica, as a measure of differentiation, becomes less significant at high SiO_2 contents. Similarly, K_2O has apparently a maximum mean value of about 5% in the Ackley Granite. Trace elements, and particularly trace element ratios, give a clearer pattern of the degree of differentiation of some of the Ackley Granite units and subunits (see Table 14).

Rubidium in the Ackley Granite is generally high throughout the pluton and only in subunit 14a (in the area southwest of Gisborne Lake) is there any strong enrichment of Rb. Thus, with the generally high K_2O values of the pluton, K/Rb ratios are in the normal range of 150 to 300 (Taylor, 1965), but are generally lower than the "average" of 230. Subunit 14a (southwest of Gisborne Lake), with a mean K/Rb ratio of 74.3, is the only unit which is significantly below the normal range. K/Rb ratios are therefore not a good guide to degree of differentiation of the various units of the Ackley Granite.

Strontium is possibly the element which gives the best representation of fractionation, although Sr is relatively mobile and may be removed by alteration. Furthermore, the addition of carbonate will strongly increase the proportion of Sr in the rock. Only in fresh rocks can Sr be used as a guide to differentiation and it is therefore suitable for the Ackley Granite. The mean Sr content (Table 14) of the four northern units (9-12) is significantly higher than for the three southern units (13-15). Similarly, Rb/Sr ratios in the northern units are in the range of 1.36 to 2.39, whereas the southern units (13-15) are much higher (2.86 to 21.02). Subunit 14a (north of Rencontre Lake) is apparently more differentiated than Unit 14 (total data) using Rb/Sr ratios but is less differentiated using K/Rb ratios.

Ratios of Ba/Rb should decrease with differentiation as Ba is removed from the magma in preference to Rb. The northern units generally have a higher mean Ba/Rb ratio than the southern units, although Unit 12 of the northern units has a lower Ba/Rb ratio than Unit 15. Unit 15 which has a high mean SiO_2 content (75.1%) contains the lowest mean Rb content of any unit of the Ackley Granite.

The various ratios indicate that the southern units are strongly differentiated compared to the northern units and, in particular, the marginal subunit 14a is the most differentiated. Although Units 13, 14 and 15 have very similar mean SiO_2 contents, the Rb/Sr and Ba/Rb ratios indicate that Unit 14, particularly subunit 14a (southwest of Gisborne Lake), is more strongly differentiated than Unit 13. This is particularly significant for the formation of economic minerals such as molybdenite. Whalen (1976) has shown, by the use of ratios of Ba/Rb and Rb/Sr, and the differentiation index, that there is a pronounced change in these indices of differentiation towards the four main molybdenite occurrences at Rencontre Lake. The numerous showings of pyrite, molybdenite, cassiterite and hematite southwest of Gisborne Lake occur in an extremely differentiated part of the Ackley Granite. Thus extreme differentiation of the granite magma must be a major factor in the formation of the various mineral occurrences.

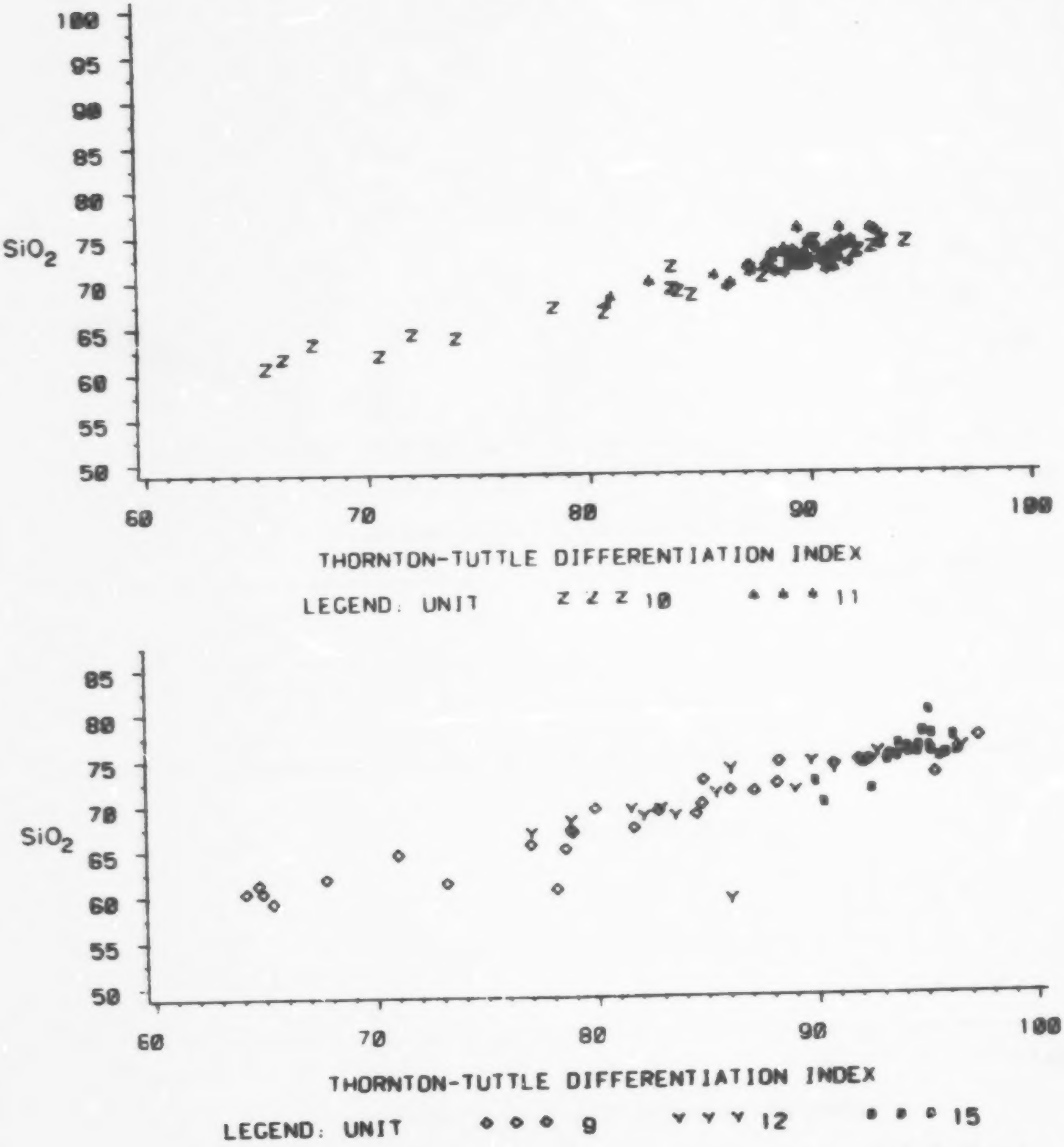


Figure 36: SiO$_2$ vs. Thornton-Tuttle Differentiation Index (both weight %) for Units 9 through 15 of the Ackley Granite.

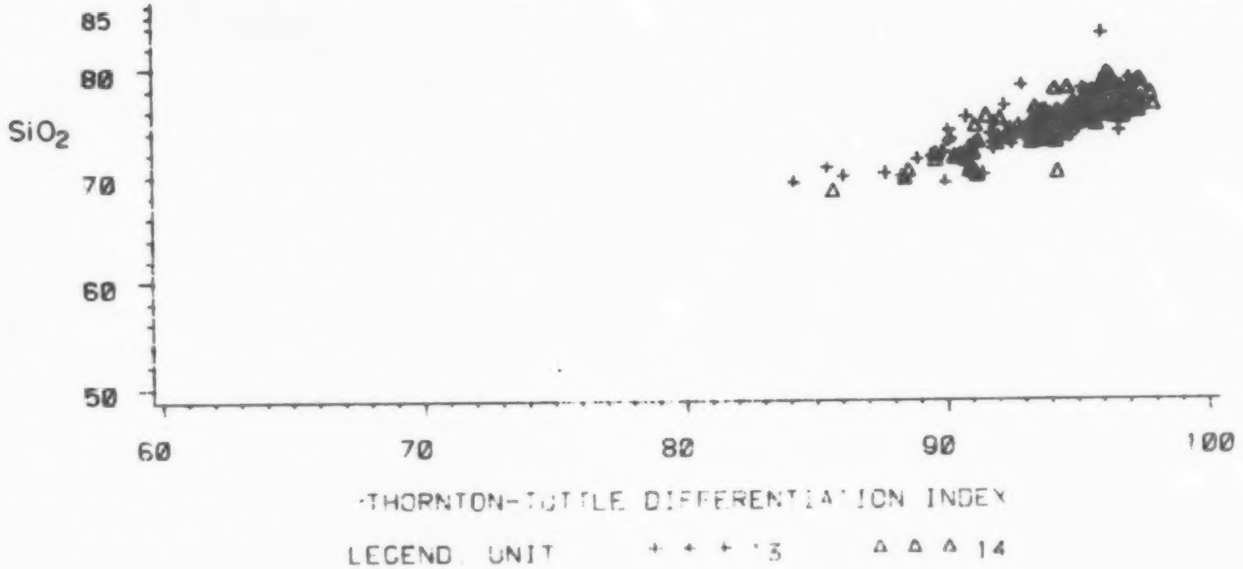
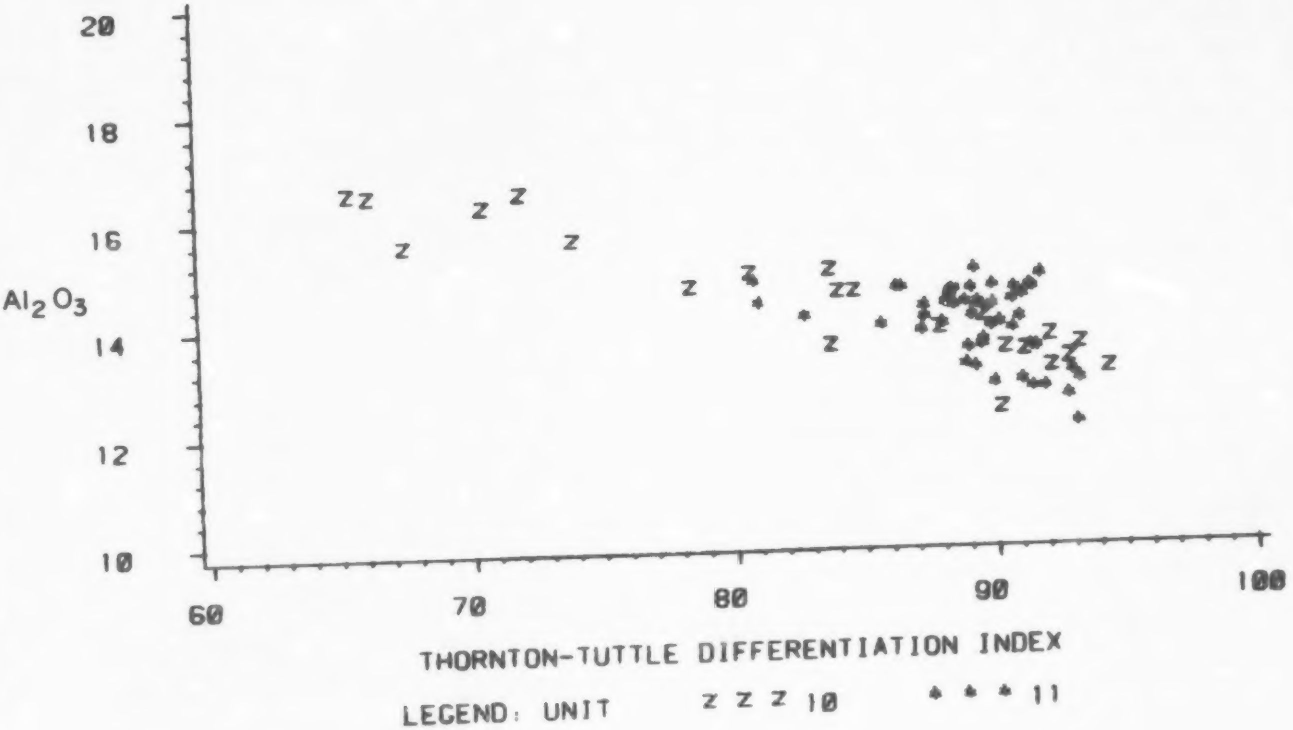


Figure 36: SiO_2 vs. Thornton-Tuttle Differentiation Index (both weight %) for Units 9 through 15 of the Ackley Granite.



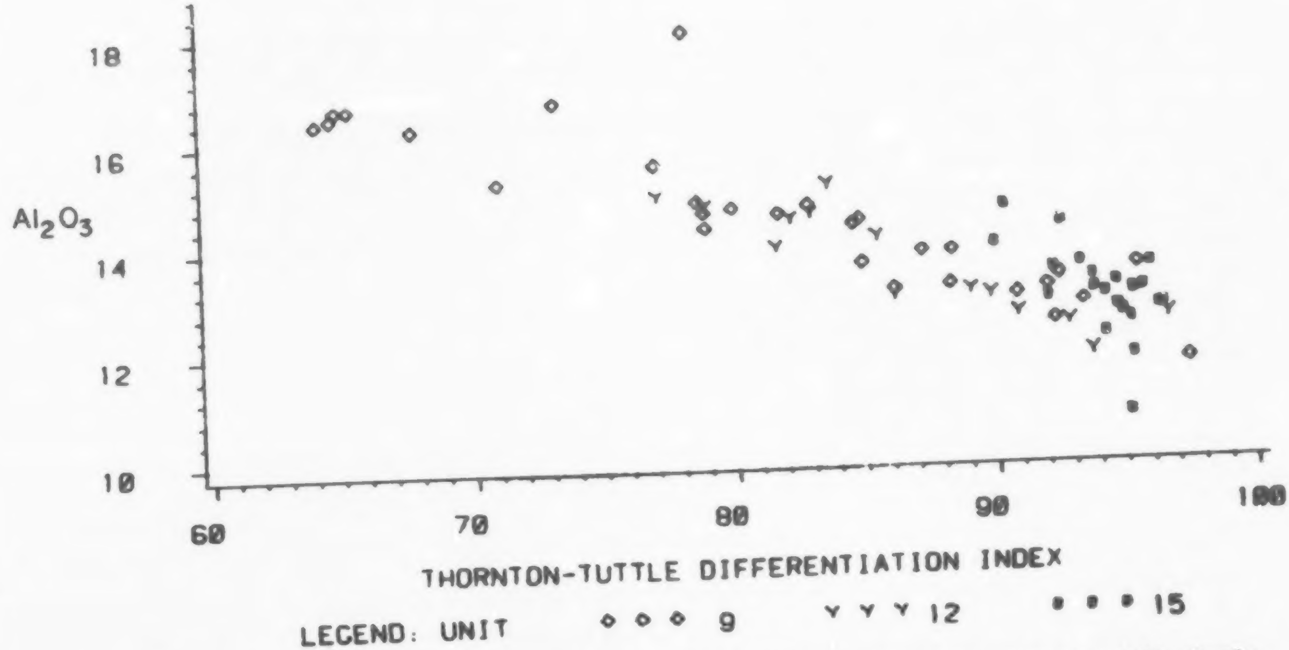


Figure 37: Al_2O_3 vs. Thornton-Tuttle Differentiation Index (both weight %) for Units 9 through 15 of the Ackley Granite.

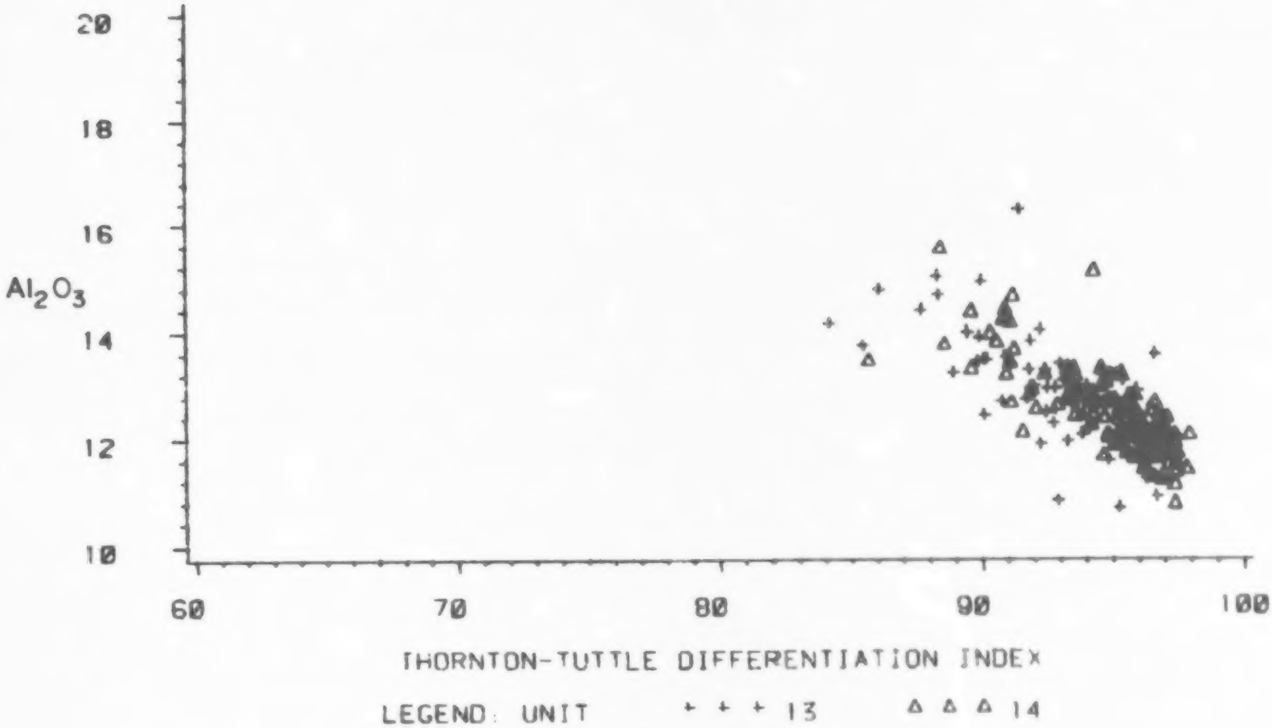


Figure 37: Al_2O_3 vs. Thornton-Tuttle Differentiation Index (both weight %) for Units 9 through 15 of the Ackley Granite.

Variation Diagrams: Major Elements

Major oxide and trace element values have been plotted against the Thornton-Tuttle Differentiation Index (TTDI). The TTDI well illustrates the variation shown by each unit. Units 9, 10, and 12 show the widest range of TTDI; Unit 11 is more restricted, and the southern units 13, 14 and 15 are extremely restricted and have the highest average TTDI (see Figure 36). The plot of SiO_2 vs. TTDI (Figure 36) shows a strong linear relationship exists between SiO_2 and TTDI. Units 9 and 10 which have the lowest mean SiO_2 content also have the widest range of SiO_2 values. Units 13, 14 and 15 have the highest mean SiO_2 and the smallest range of SiO_2 from 70% to 80%. The plot of Al_2O_3 vs TTDI (Figure 37), for the northern units, shows a steady decrease with increasing TTDI. The amount of decrease of Al_2O_3 per unit TTDI is greater in the southern units, where the TTDI is higher than in the northern units. The northern units contain 16% Al_2O_3 at a TTDI of about 73 and reach 12% Al_2O_3 at about TTDI 94. The southern units show the same range of Al_2O_3 contents between TTDI 87 and 97.

The oxides MgO, CaO, MnO, FeO_{total}, TiO_2 and P_2O_5 show a steady decrease with increasing TTDI and follow the same linear trend (Figures 38 to 43). Soda variation with TTDI patterns for Units 9, 10 and 12 (Figure 44) are similar and show a relatively constant Na_2O value. Unit 11 does not follow this pattern and shows a relatively well developed trend of decreasing Na_2O with increasing TTDI. Units 13, 14 and 15 show a pattern of decreasing Na_2O with increasing TTDI parallel to that shown by Unit 11. Potash shows a general increase with increasing TTDI in Units 9-12 (Figure 45). The rate of increase of K_2O in Unit 11 however is greater than in Units 9, 10 and 12. Units 13-15 show a trend of constant to slightly decreasing K_2O content with increasing TTDI.

In summary, the changes in major element concentrations with increasing differentiation index indicate that there are three main trends for the units of the Ackley Granite. Units 9, 10 and 12 define one trend; Unit 11 forms a separate trend and Units 13, 14 and 15 form another separate trend.

Fractionation of biotite and calcic plagioclase are probably the most significant controls of the trends shown by Units 9 to 12. The decrease in Na_2O shown by Unit 11 and Units 13 to 15 must be controlled by sodic plagioclase as no other sodic mineral is available. Biotite ± hornblende fractionation would control the decrease in FeO_{total} and MgO. Alkali-feldspar fractionation would cause the eventual depletion of K_2O and, with sodic plagioclase, would increase the rate of depletion of Al_2O_3.

Variation Diagrams: Trace Elements

The trace elements have been plotted, on a logarithmic scale, against TTDI. Lithium shows a pattern of relatively constant values with increasing TTDI, then a decrease at the higher values of the TTDI (Figure 46). Unit 14a (southwest of Gisborne Lake) which has the highest mean Li content and numerous newly discovered mineral showings, contains most of the higher Li values. Rubidium shows a pattern of gradually increasing values with increasing TTDI (Figure 47), although the analyses with the highest TTDI in Units 13 and 14 show a pronounced increase in Rb values. Strontium and Ba show a pattern which is the mirror image of the Rb pattern (Figures 48 and 49). Strontium in Unit 11 is generally higher than in the other units at the same TTDI. A particularly prominent feature of Units 13 and 14 is the rapid decrease in Sr and Ba contents over a small range of TTDI. Zirconium values show a gradual decrease with increasing differentiation in the northern units (Figure 50). The trend shown by the southern units

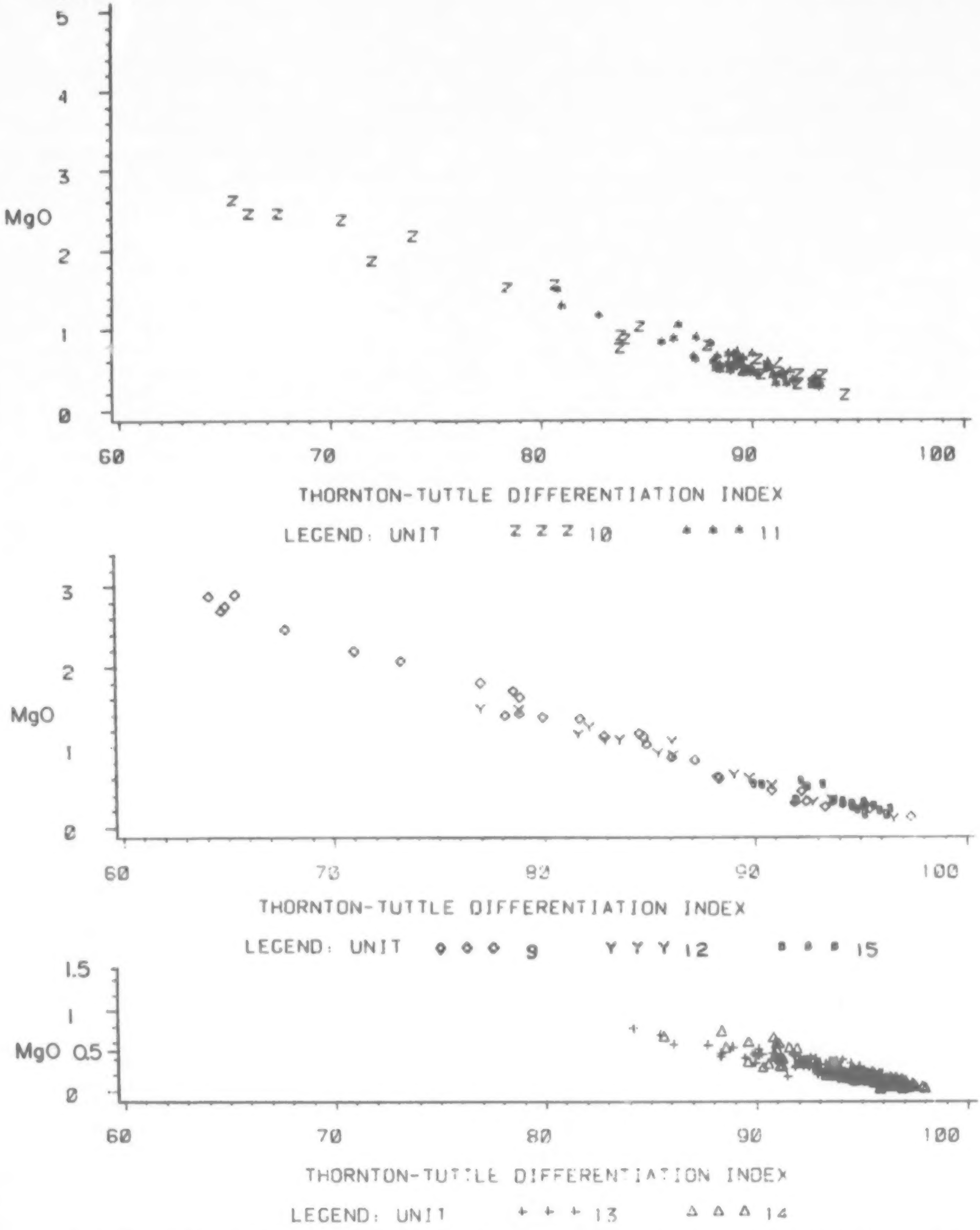


Figure 38: MgO vs. Thornton-Tuttle Differentiation Index (both weight %) for Units 9 through 15 of the Ackley Granite.

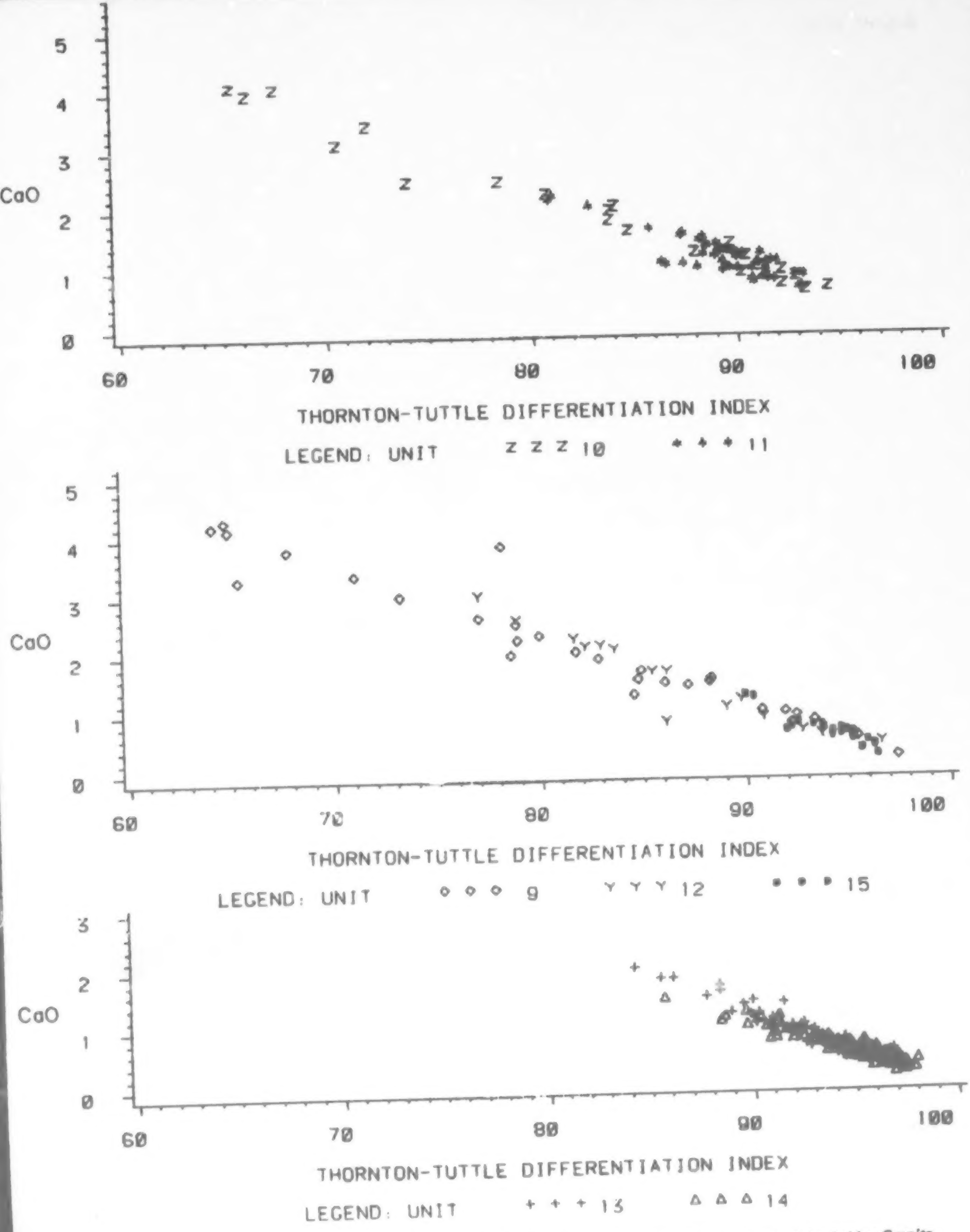


Figure 39: CaO vs. Thornton-Tuttle Differentiation Index (both weight %) for Units 9 through 15 of the Ackley Granite.

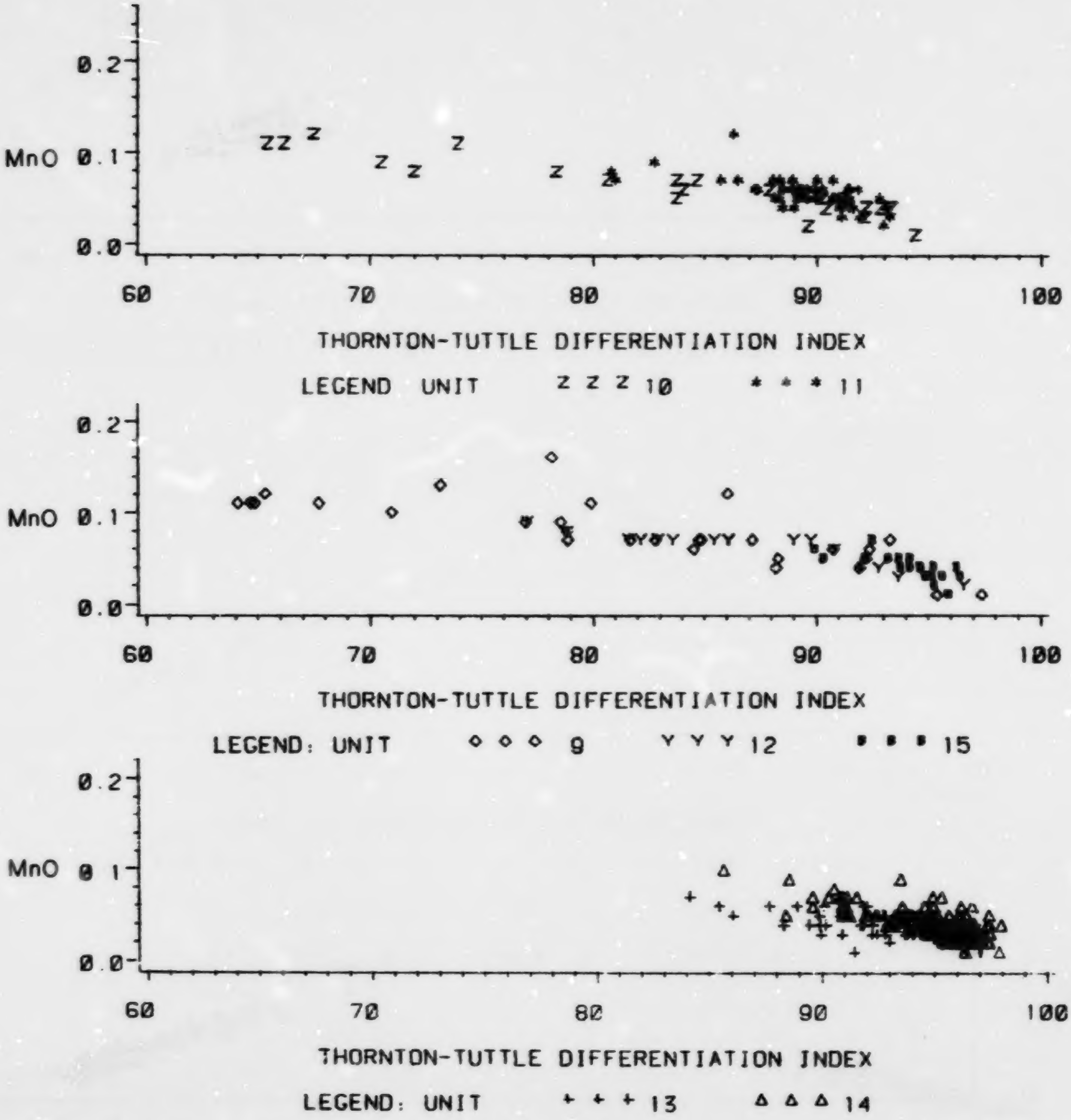


Figure 40: ***MnO vs. Thornton-Tuttle Differentiation Index (both weight %) for Units 9 through 15 of the Ackley Granite.***

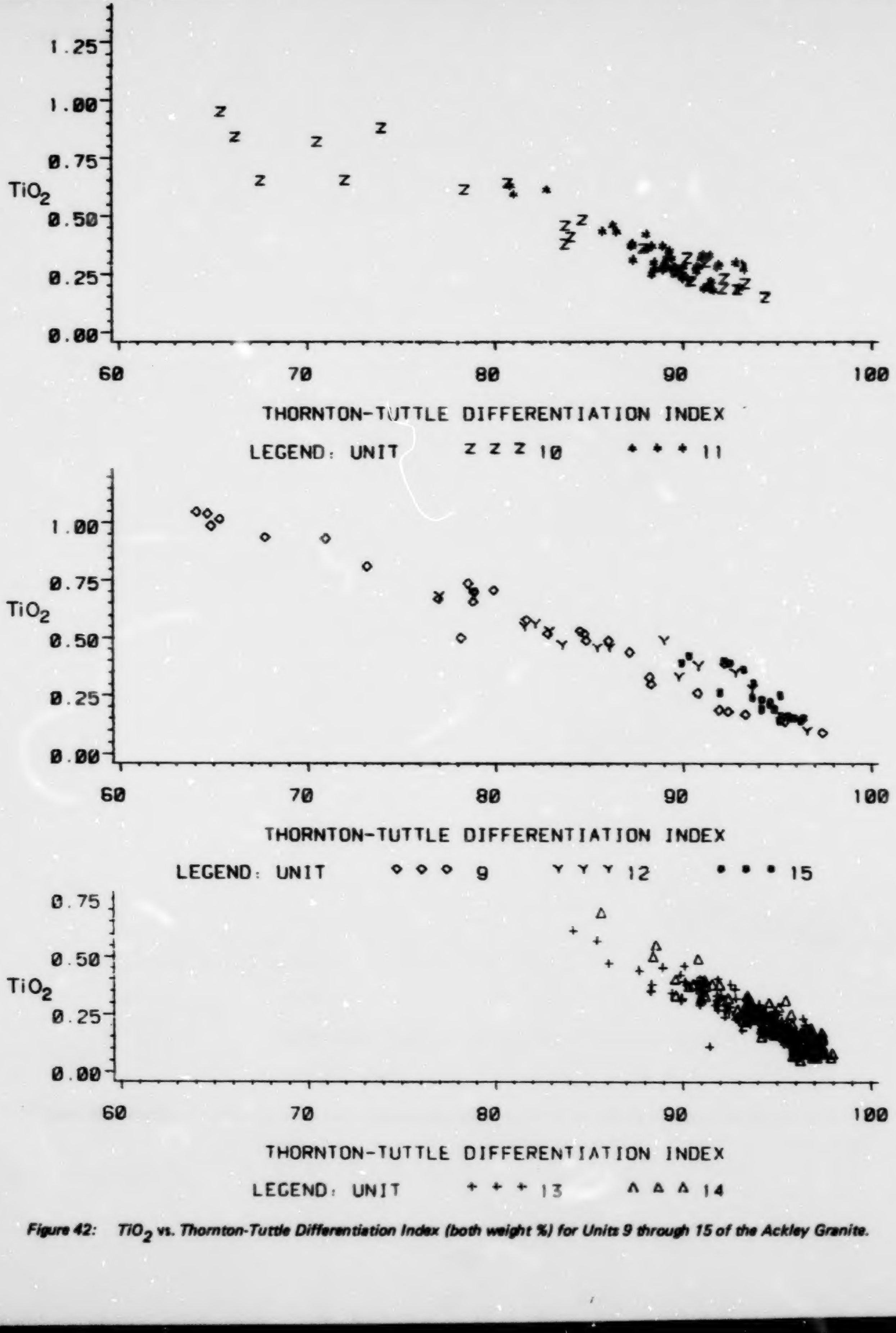


Figure 42: TiO_2 vs. Thornton-Tuttle Differentiation Index (both weight %) for Units 9 through 15 of the Ackley Granite.

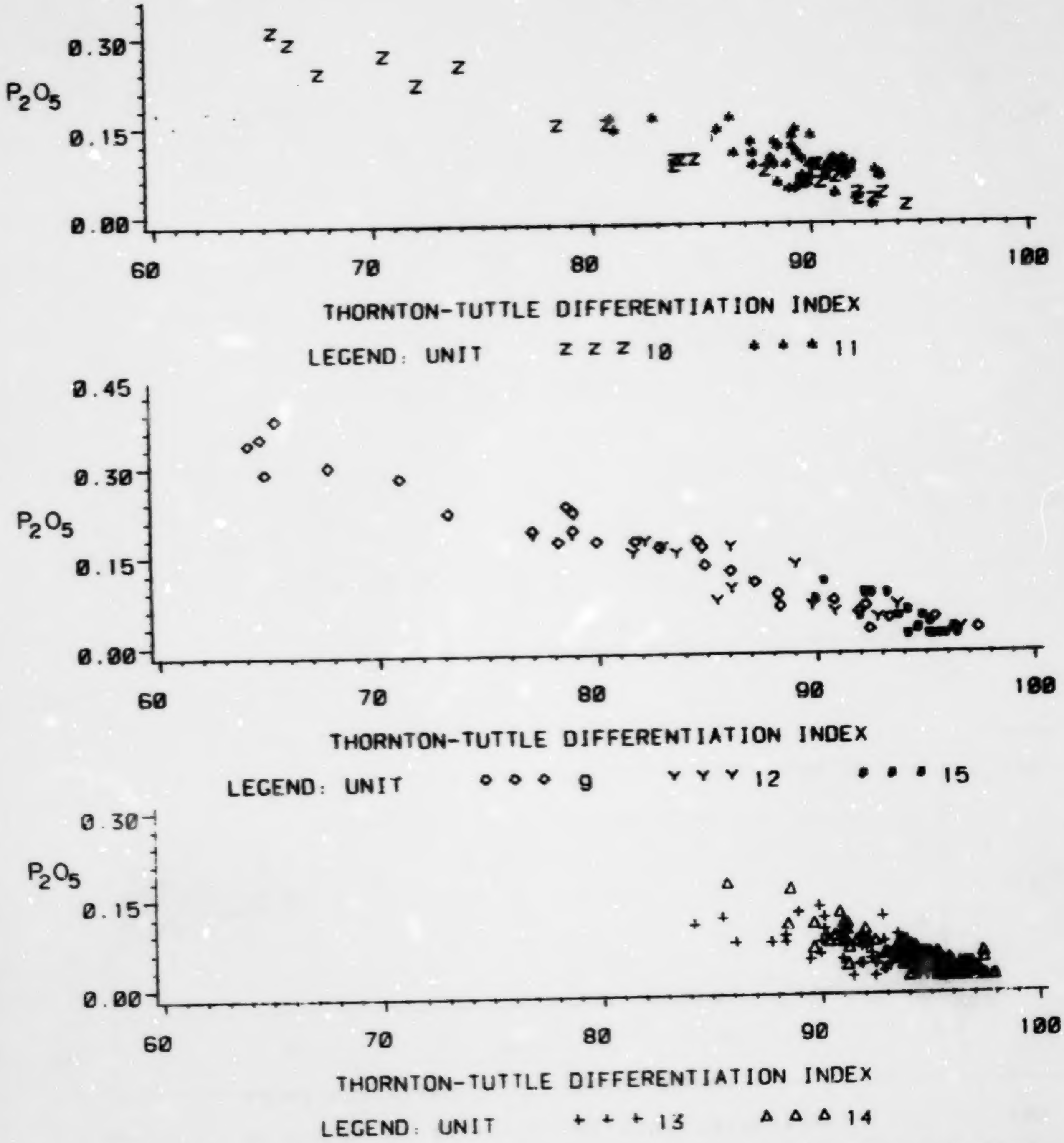


Figure 43: P_2O_5 vs. Thornton-Tuttle Differentiation Index (both weight %) for Units 9 through 15 of the Ackley Granite.

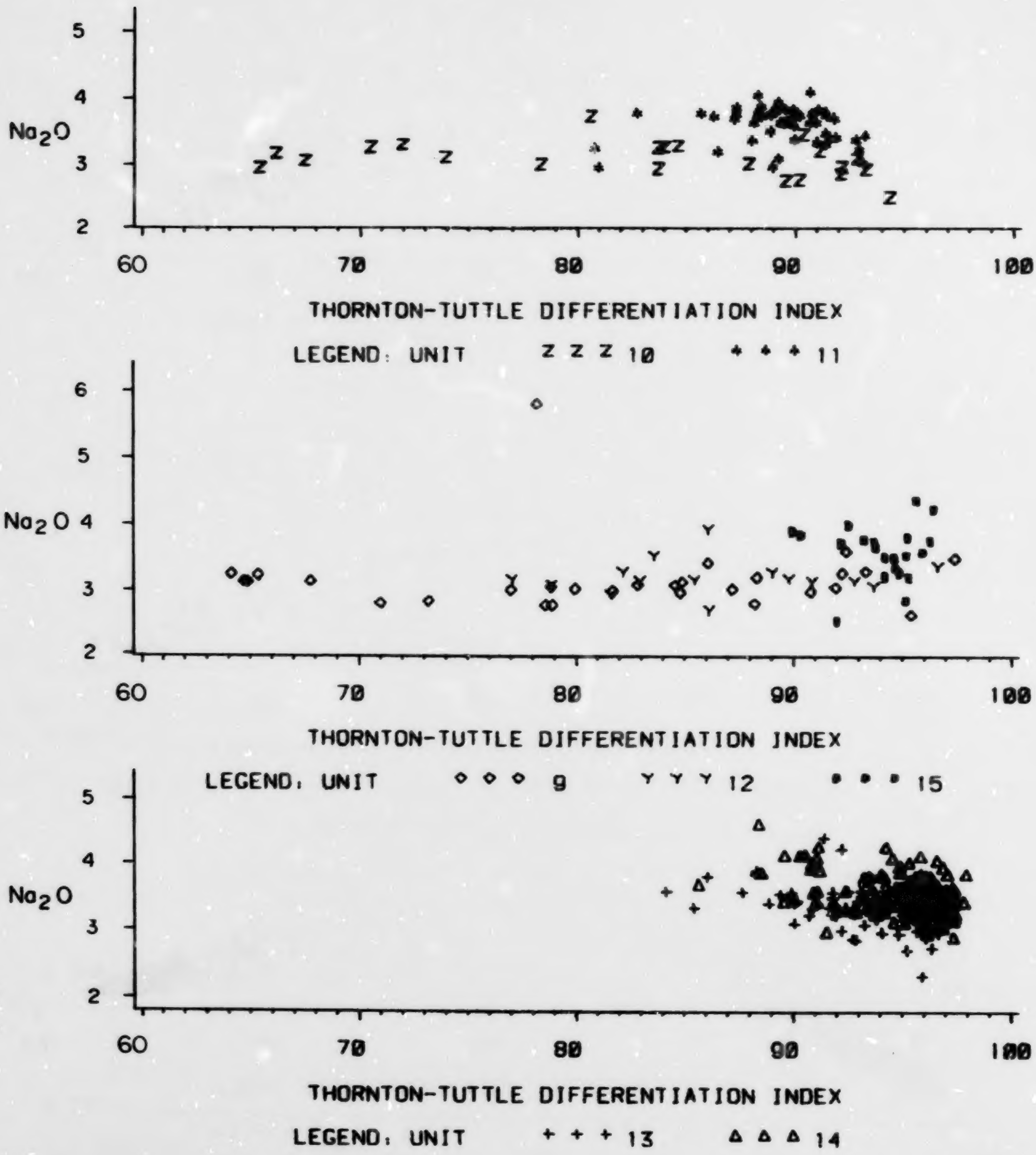


Figure 44: Na_2O vs. Thornton-Tuttle Differentiation Index (both weight %) for Units 9 through 15 of the Ackley Granite.

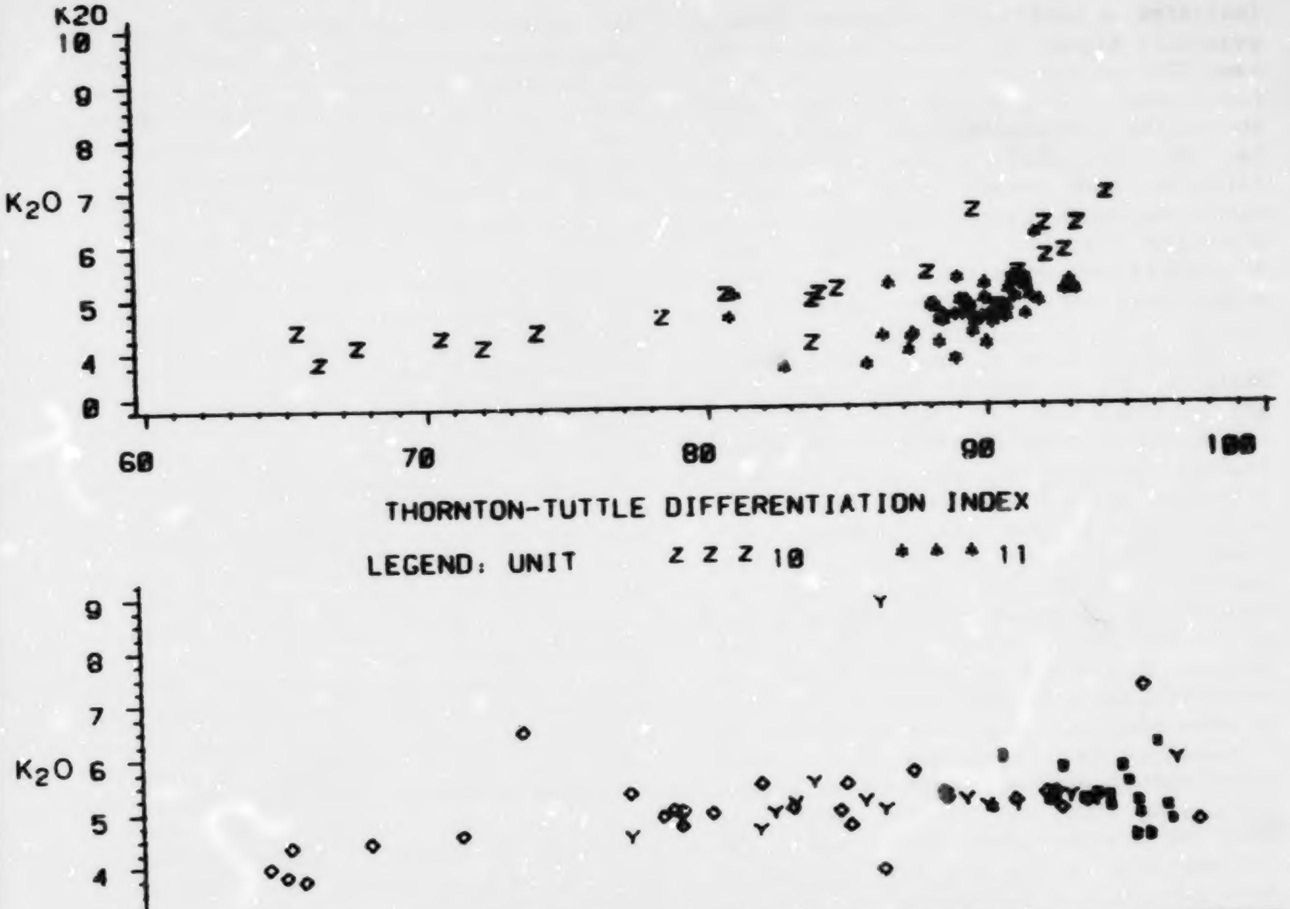


Figure 45: *K_2O vs. Thornton-Tuttle Differentiation Index (both weight %) for Units 9 through 15 of the Ackley Granite.*

indicates a more rapid decrease from a generally higher Zr concentration at the same TTDI as the northern units to about the same Zr concentration with increasing differentiation. Cerium, Cr, La, Zn, Nb, Ga, Y, V, Cu, and Pb (diagrams not shown) show the normal variation with increasing TTDI. Cu is strongly depleted in the more differentiated granites and only shows minor local enrichment (see Appendix I).

Fluorine shows a general decrease in Units 9, 10, 12 and 15 from about 1000 g/t to about 100 g/t (Figure 51). This is probably related to the decreasing biotite content of the granites with differentiation. The more leucocratic units (11, 13 and 14), however, have other trends. Unit 11 shows a general increase in F, the higher fluorine contents being found within subunit 11b, which may be a result of the hydrothermal alteration which has formed the muscovite and sericite. Unit 13 and Unit 14 show similar trends but Unit 14 shows a possibly important deviation. Both units show a general decrease in F with increasing TTDI, but several samples in Unit 14 are enriched in F and these include most of the analyses of samples from subunit 14a (southwest of Gisborne Lake). Recent determinations of F on new samples from this area are given in Table 16. The high F content of the granite in this area also coincides with that found in lake sediments (Butler and Davenport, 1979). The generally low biotite content of the granitoids in this area indicates that biotite is not the host and the F has therefore been introduced probably by hydrothermal fluids. Fluorite occurs in the greisens and has also been found in a few thin sections of the granitoids in this area.

Uranium and Th show a gradual increase in concentration with increasing TTDI (Figures 52 and 53). The rate of increase, however, is much more rapid in Units 11, 13, 14 and 15 than in the other units and probably reflects the strong fractionation of the granitic magma illustrated by Sr and K/Rb ratios. The highest U and Th values occur in subunit 14a (southwest of Gisborne Lake) in the marginal facies, and in the late stage aplites which cut the granite. This agrees with the spectrometer survey carried out during sample collection which gave total count readings of 2 to 3 times background in this area.

The Mo values for the Ackley Granite are generally low. There are scattered anomalous values but certainly no clear relationship between TTDI and Mo content (Figure 54). The formation of the significant molybdenite occurrences near Rencontre Lake must be related to efficient concentration of Mo in the granitic magma, and the formation of pockets of this Mo-enriched phase in accordance with the scheme proposed by Whalen (1976, 1980) and some of the earlier workers, *e.g.* White (1939). Whalen (1976) shows that there is a strong increase in Rb/Sr and TTDI and decrease in Ba/Rb ratios towards the contact. This pattern also occurs to the east, in Unit 14, where low grade molybdenite occurrences are also found close to the contact. The model, proposed by Whalen (1976) and earlier workers (Nolan, 1969), of a structural trap for the Mo-rich magma is supported by the lack of sizable molybdenite occurrences to the east, where geochemical indicators show a high Mo potential based on the high degree of differentiation of the granite.

Tin analyses of the Ackley Granite show that the northern units (9, 10, 11 and 12) have a consistently low Sn content (less than 3 g/t) which does not vary with increasing differentiation index (Figure 55). The southern units (13, 14, 15) show a distinctly different pattern, with generally a strong increase in Sn content with increasing differentiation index. Units 13 and 14 are particularly enriched in Sn with numerous samples containing more than the background value of 3 g/t Sn. Numerous samples, however, show no Sn enrichment despite having a high differentiation index. In Unit 13, the

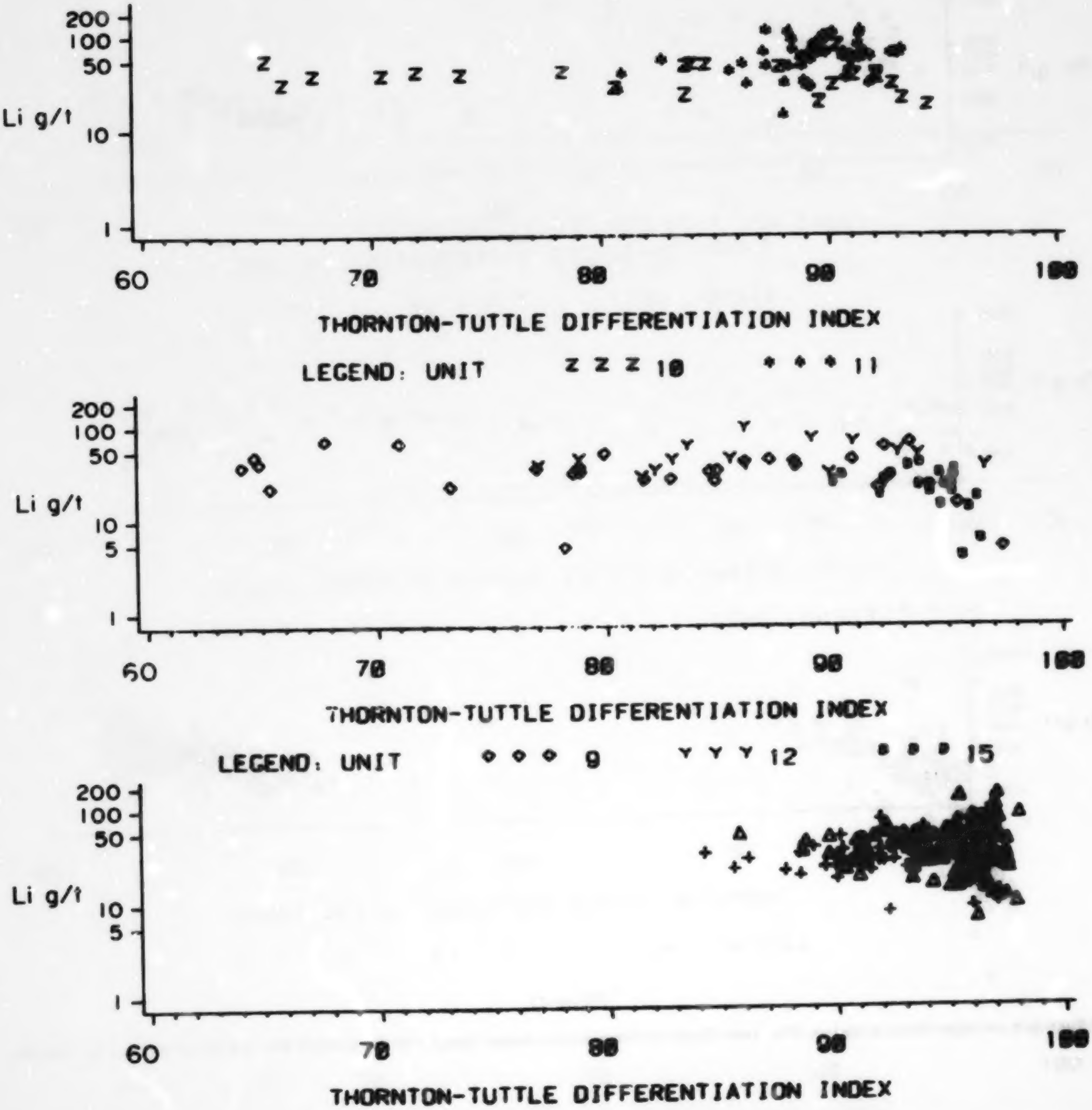


Figure 46:

Lithium (g/t, on logarithmic scale) vs. Thornton-Tuttle-Differentiation Index (weight %) for Units 9 through 15 of the Ackley Granite.

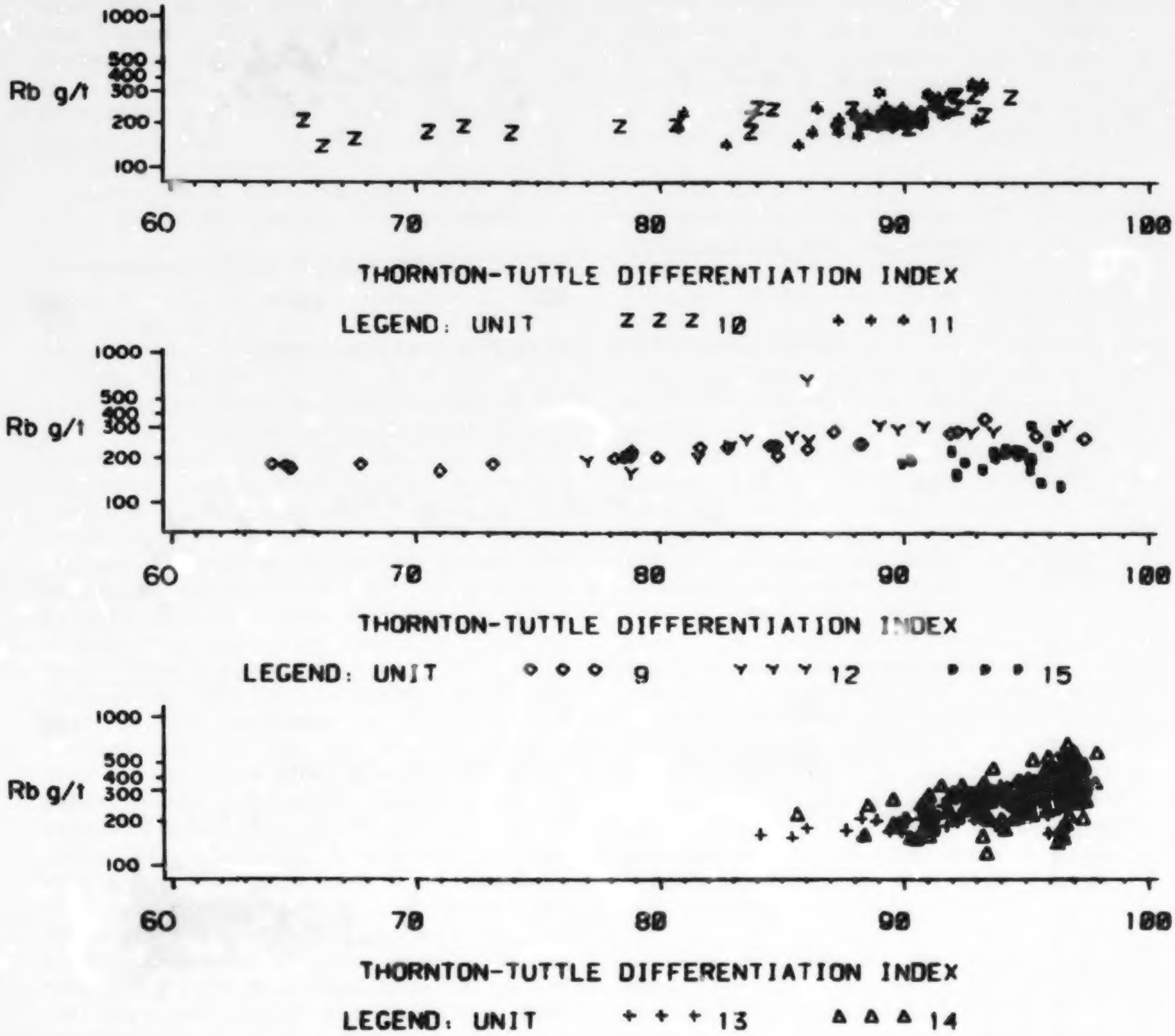


Figure 47:

Rubidium (g/t, on logarithmic scale) vs. Thornton-Tuttle Differentiation Index (weight %) for Units 9 through 15 of the Ackley Granite.

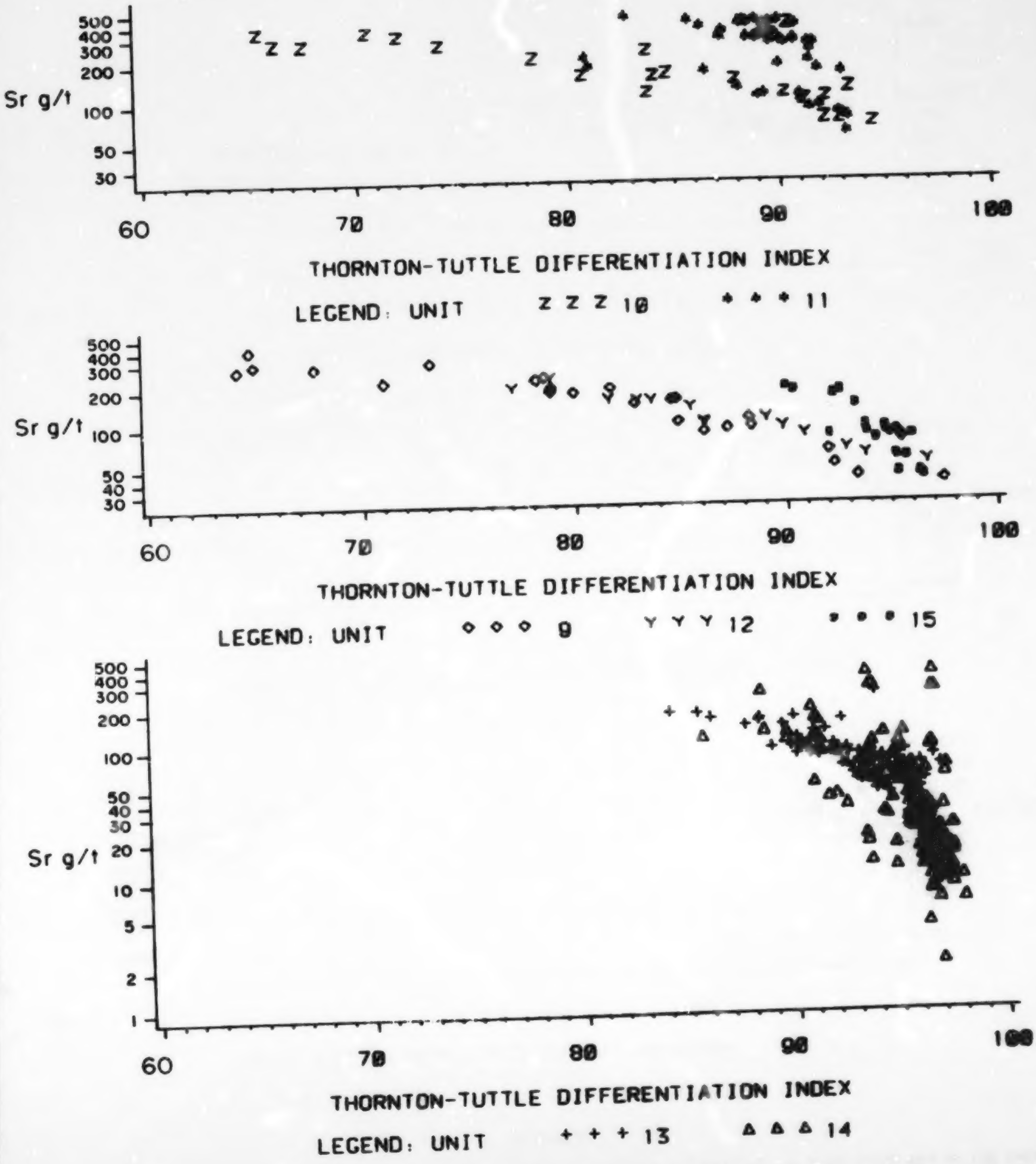


Figure 48:

Strontium (g/t, on logarithmic scale) vs. Thornton-Tuttle Differentiation Index (weight %) for Units 9 through 15 of the Ackley Granite.

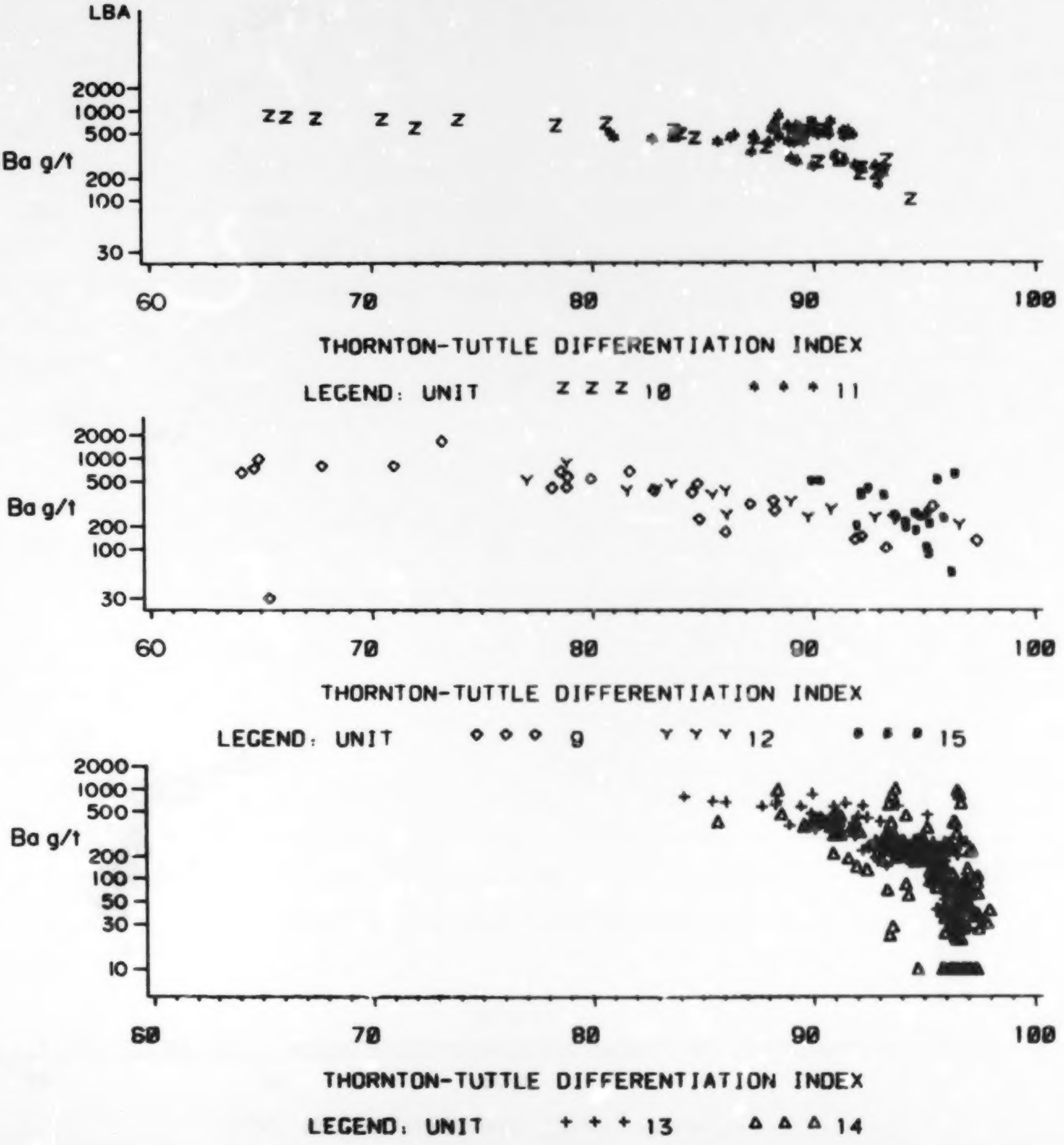


Figure 49:

Barium (g/t, on logarithmic scale) vs. Thornton-Tuttle Differentiation Index (weight %) for Units 9 through 15 of the Ackley Granite.

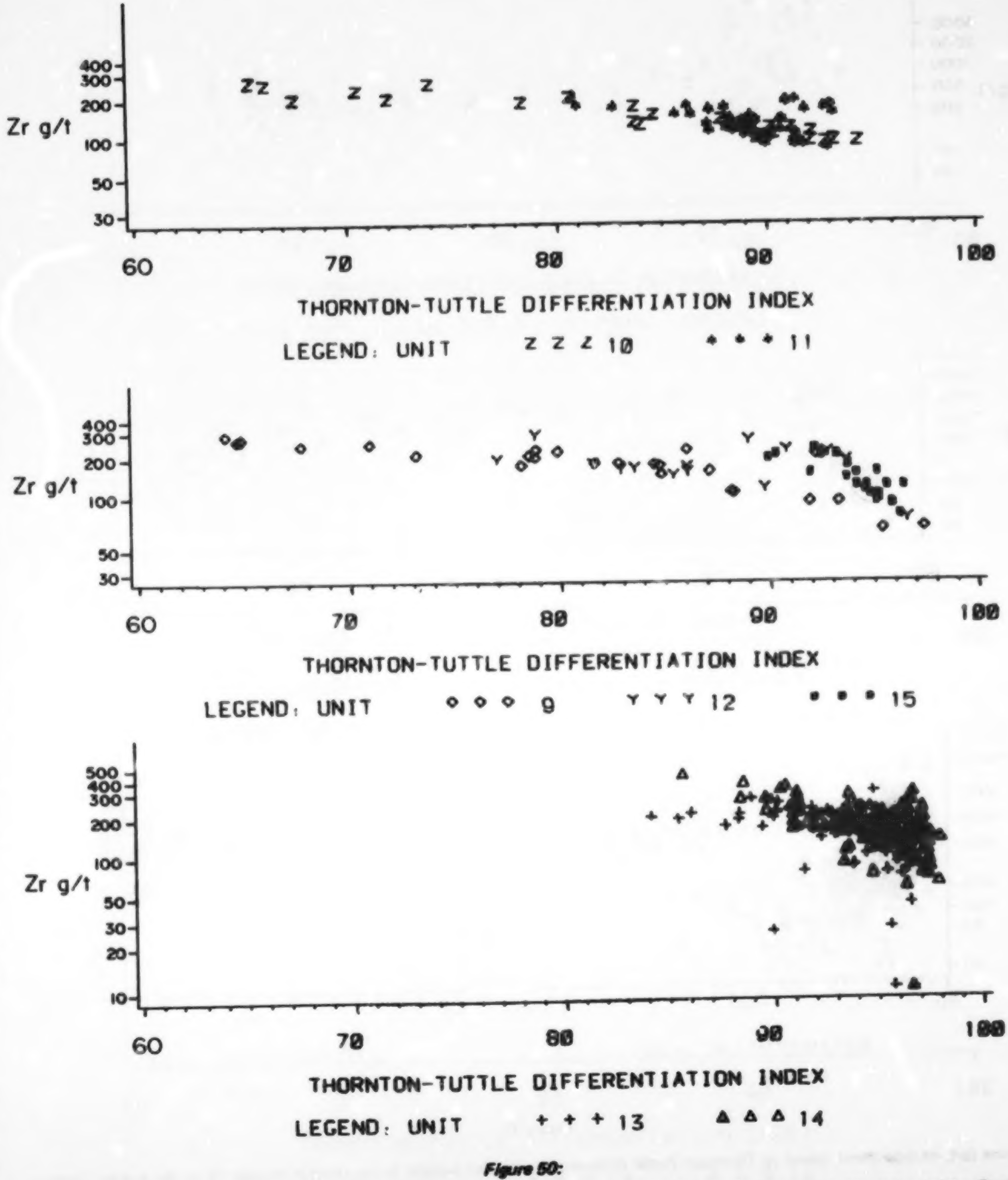


Figure 50:

Zirconium (g/t, on logarithmic scale) vs. Thornton-Tuttle Differentiation Index (weight %) for Units 9 through 15 of the Ackley Granite.

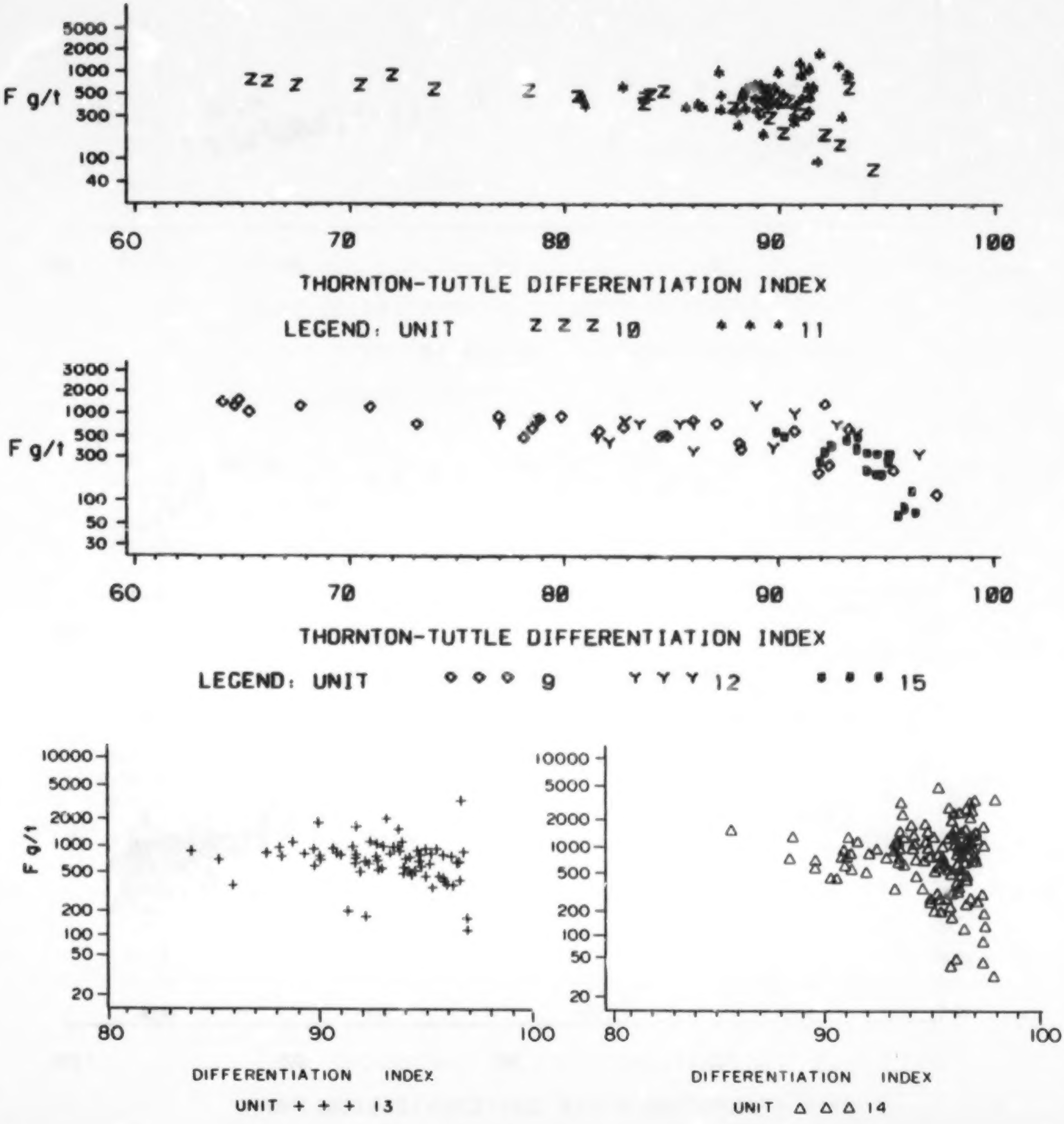


Figure 51:

Fluorine (g/t, on logarithmic scale) vs. Thornton-Tuttle Differentiation Index (weight %) for Units 9 through 15 of the Ackley Granite.

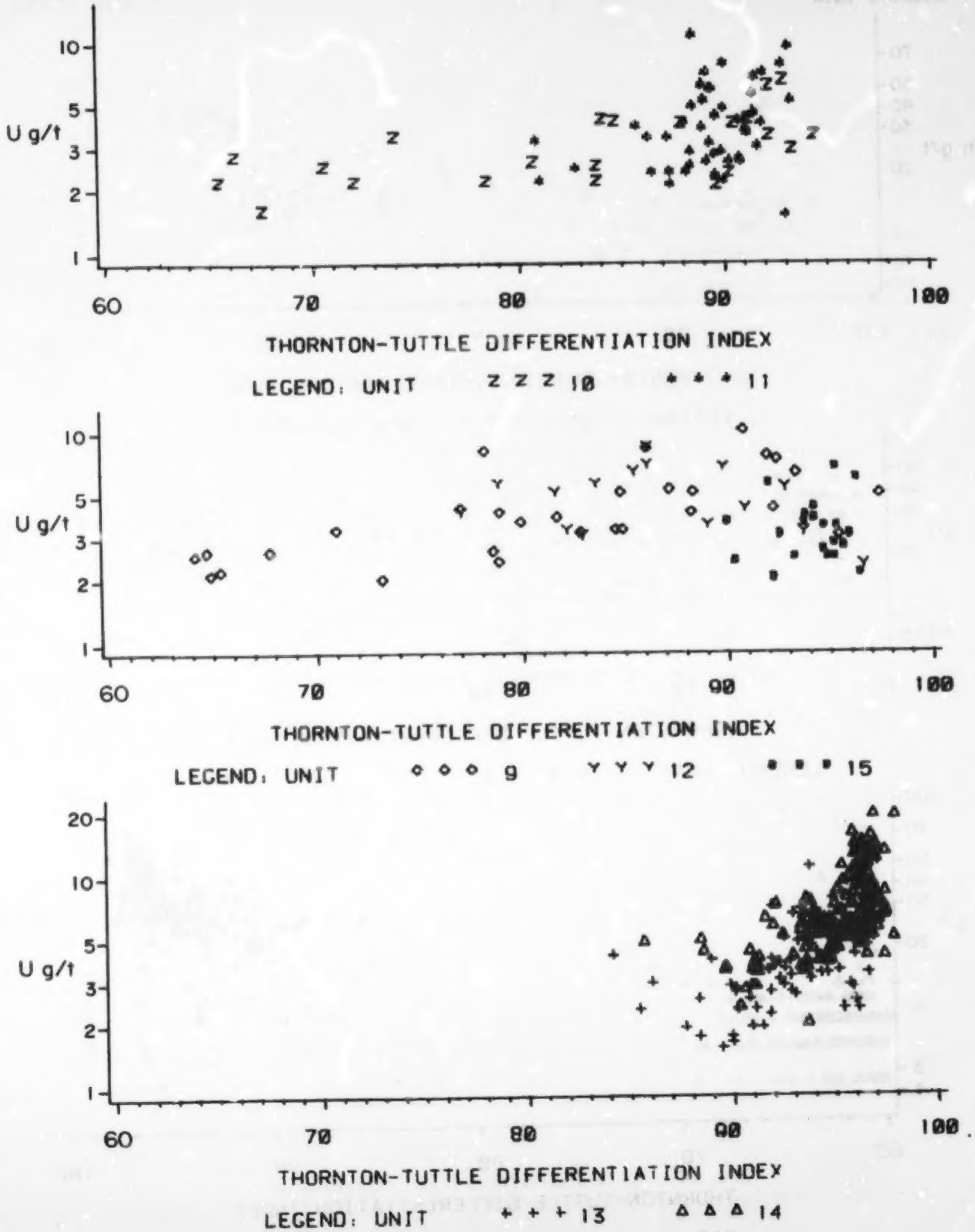


Figure 52:

Uranium (g/t, on logarithmic scale) vs. Thornton-Tuttle Differentiation Index (weight %) for Units 9 through 15 of the Ackley Granite.

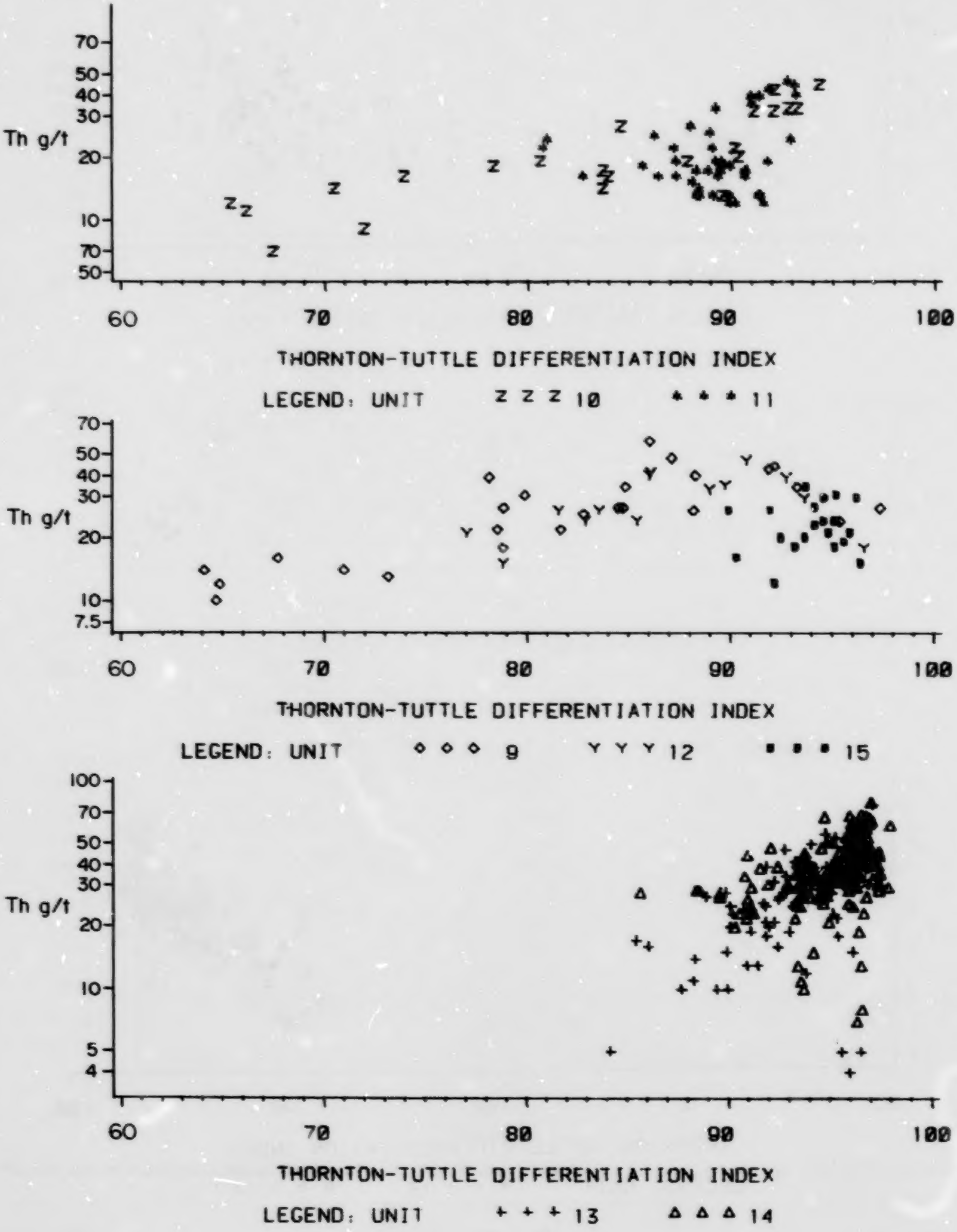


Figure 53: *Thorium (g/t, on logarithmic scale) vs. Thornton-Tuttle Differentiation Index (weight %) for Units 9 through 15 of the Ackley Granit*

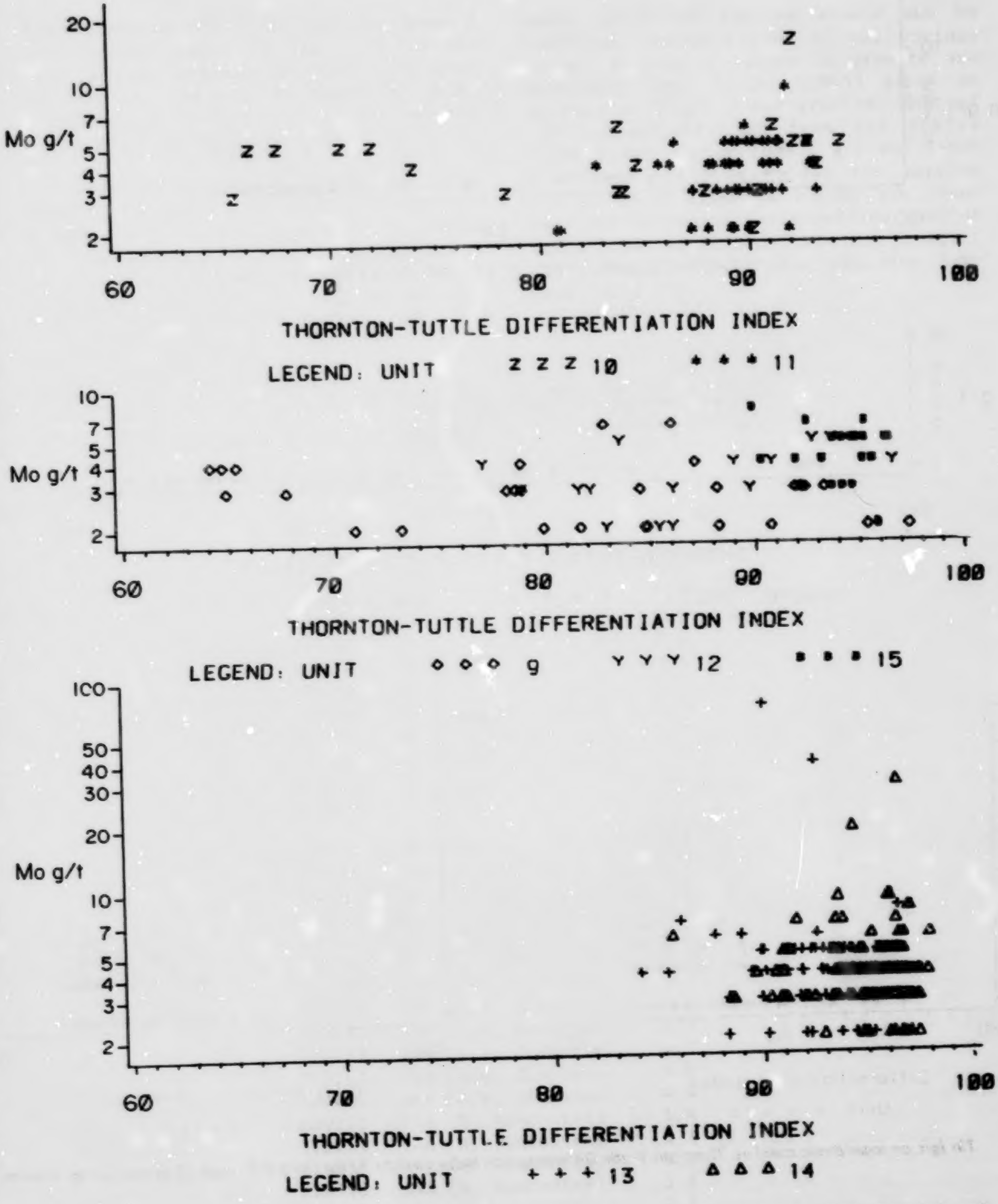


Figure 54: *Molybdenum (g/t, on logarithmic scale) vs. Thornton-Tuttle Differentiation Index (weight %) for Units 9 through 15 of the Ackley Granite.*

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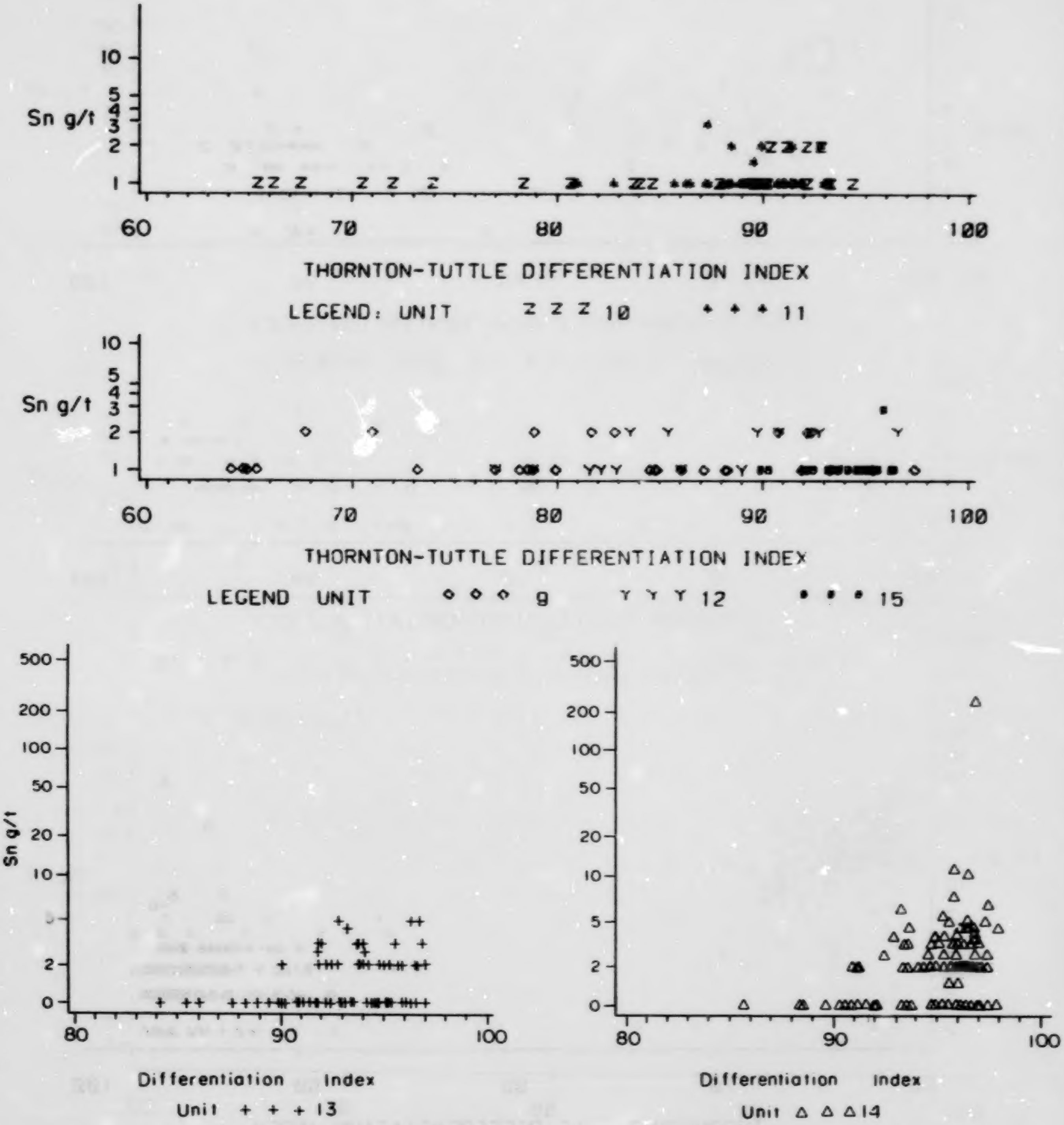


Figure 55: ***Tin (g/t, on logarithmic scale) vs. Thornton-Tuttle Differentiation Index (weight %) for Units 9 through 15 of the Ackley Granite.***

higher Sn values (*i.e.* greater than 2 g/t) occur mainly in the belt to the west of the Precambrian roof pendants. In Unit 14, the main Sn anomalies (*i.e.* greater than 5 g/t Sn) occur between Rally Pond and Gisborne Lake.

Selected samples from the main sampling program have been analyzed for W and the data are presented in Table 15. Samples were selected on the basis of anomalous concentrations of other elements such as U, F, Li, Mo and Sn. Thus the statistical analyses of this small group of samples should not be taken as representative of the various units. Average W values in granite are generally low. Taylor (1965) gives an average of 2 g/t W for granite. Most of the values obtained from the Ackley Granite are higher than 2 g/t and reach a maximum of 10.3 g/t for the samples listed. Much higher W values are found in a few molybdenite-mineralized samples taken from the Motu molybdenite prospect and a hematite vein near Gisborne Lake (see Table 15).

TABLE 15: TUNGSTEN ANALYSES OF SELECTED SAMPLES FROM THE ACKLEY GRANITE

Sample	Unit	W g/t
220517	9	1.8
220052	10	6.3
220087	11B	3.5
220154	11A	1.1
220137	13	2.5
220361	13	2.6
220386	13	9.5
220412	13	10.1
220432	13	4.5
220326	14	5.7
220450	14	3.8
220552	14	3.4
220669	14	4.2
220671	14	10.3
220707	14	2.8
220711	14	3.3
220713	14	4.0
220730	14	2.2
220754	14	4.3
220755	14	3.3
220757	14	2.3
220332	14A (S.W. Gisborne)	6.1
220335	14A (S.W. Gisborne)	4.9
220339	14A (S.W. Gisborne)	6.2
220717	14A (S.W. Gisborne)	5.5
220721	14A (S.W. Gisborne)	4.3
220252	14A (N. Rencontre)	1.9
220253	14A (N. Rencontre)	6.8
220257	14A (N. Rencontre)	3.0
220358	14A (N. Rencontre)	5.5
220153	15	1.5

GEOCHEMISTRY AND MINERALOGY OF THE MINERALIZED AREA SOUTHWEST OF GISBORNE LAKE (SUBUNIT 14a)

Detailed mapping of the Ackley Granite contact between Gisborne Lake and Rally Pond (Figures 56a and b) was carried out following the main analytical program. Analysis of the data from this area highlighted the southern contact as being highly anomalous in Sn and F, and also as having geochemical characteristics similar to the Rencontre lake molybdenite showings. Mapping of the contact area revealed mineralization and alteration which had been described only briefly by Ricketts and Bumgarner (1954) in their description of the Anesty Hill molybdenite showings. Extensive greisen development and hematite mineralization were discovered. The quartzites of Ricketts and Bumgarner (*op. cit.*) are reinterpreted as topazite greisen, and not screens of sediment as they originally reported. A variety of micaceous greisen (here termed gray greisen) was also discovered, as were hematite-rich quartz veins and quartz pods and veinlets.

Samples of the various rock types were collected from the area between Gisborne Lake and Rencontre Lake. These samples have been analyzed for major elements and 17 trace elements. Three samples were assayed for Au but none was detected. The analyses are listed in Table 16.

The fresh, unmineralized granite samples from the contact area show a similar chemistry to the samples collected to the north of the contact, particularly in SiO_2, Al_2O_3, Na_2O and K_2O, Rb and F content. The granites are highly differentiated with high SiO_2 and Rb/Sr ratios. The molybdenite-bearing samples, from the Wylie Hill and Motu showings, have a major and trace element chemistry similar to the granite from the contact area to the east, apart from slightly lower Na_2O, much higher Mo, and slightly elevated Sn and W values.

Three samples of quartz from small veins and pods were analyzed. The quartz veins and quartz pods commonly contain minor amounts of orthoclase feldspar. The presence of the feldspar is clearly reflected in the contents of Al_2O_3, Na_2O, and K_2O in these samples. The proportion of feldspar in the quartz veins is generally less than 2%. If the Li is contained in the feldspar, then the feldspars are highly enriched in Li. This would also indicate formation of the quartz veins and pods during very late stage crystallization of the granite magma. Whalen (1976, 1980) has postulated a similar model for the genesis of the quartz veins and very large, terminated, zoned beta-quartz crystals at the Crow Cliff-Dunphy Brook molybdenite showing at Rencontre Lake. No mineralization was found in the area of the sampled quartz veins and pods, although coarse molybdenite crystals occur in quartz pods about 2 km west of Anesty Hill (Dickson, 1982). Tin, W and Mo contents are very low in quartz veins 221157 and 221159, from west of Long Harbour, compared to quartz vein 221155, from east of Long Harbour.

Quartz-specularite veins are common between locality 221149 (1 km east of Sage Pond) and Anesty Hill and vary greatly in thickness and abundance of specularite. The veins are generally less than 5 mm thick and commonly cut the topazite greisen veins. The thickest specularite vein (sample 221159) cuts medium-coarse grained, equigranular granite, about 100 m from the contact with the Precambrian metasediments. In this area, the quartz-hematite vein consists mainly of fine grained quartz, with minor feldspar and granite, which is cut by veinlets of specularite. Analysis of the vein shows that it contains 8.33% $Fe_2O_{3(total)}$ and 87.6% SiO_2. The small proportion Al_2O_3, Na_2O and K_2O reflect the small proportion of feldspar and granitic material in the vein. Trace element analysis indicates that the vein is highly enriched in Sn (177 g/t), W (41.4 g/t), Mo (19 g/t) and

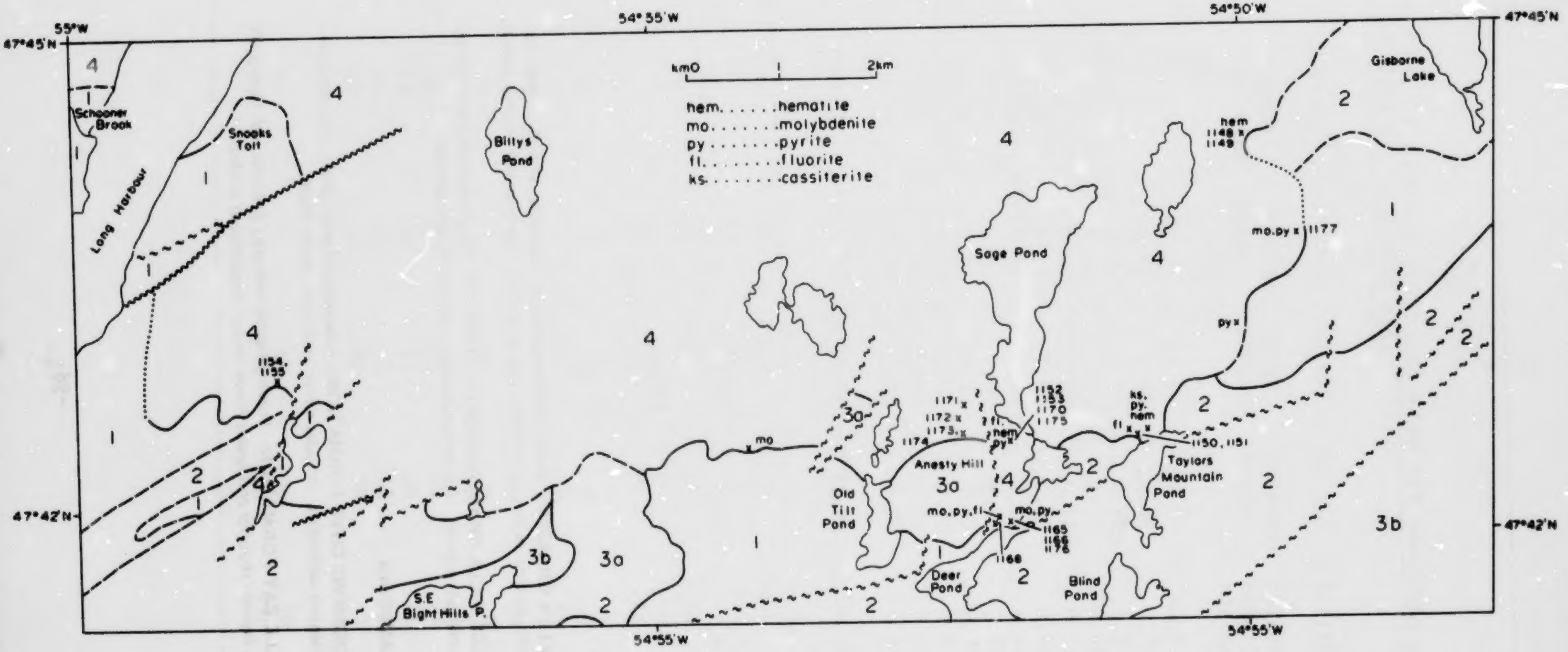
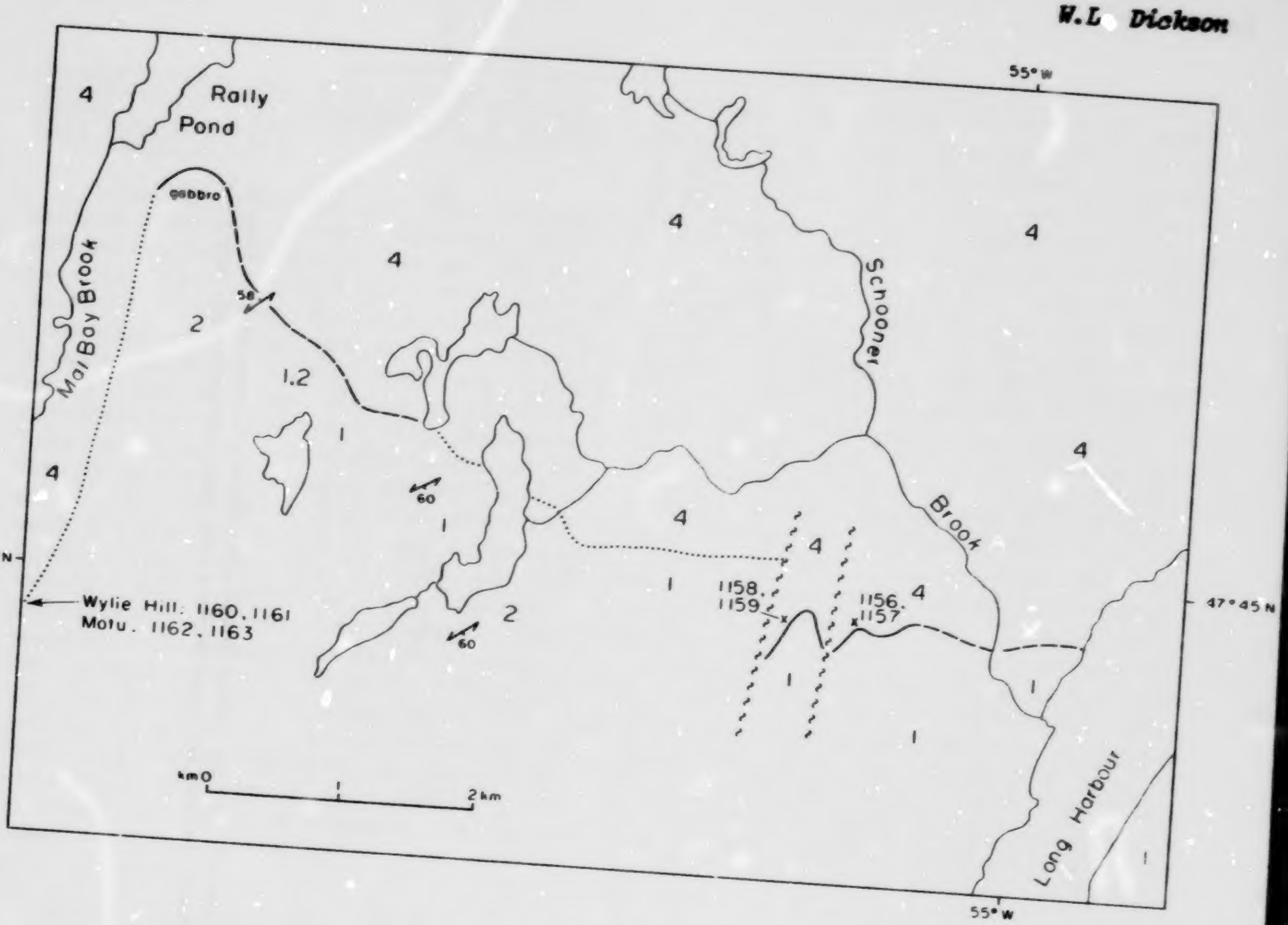

55°W
54°55'W
54°50'W
47°45'N
47°42'N
54°55'W
54°55'W
km0 1 2km
hem. . . . . .hematite
mo. . . . . . .molybdenite
py . . . . . . .pyrite
fl. . . . . . . .fluorite
ks. . . . . . . .cassiterite
Schooner Brook
Long Harbour
Snooks Tolt
Billys Pond
Sage Pond
Gisborne Lake
Anesty Hill
Old Till Pond
Deer Pond
Blind Pond
Taylors Mountain Pond
S.E Bight Hills P.
1154, 1155
1171 x
1172 x
1173 x
1174
1152
1153
1170
1175
1150, 1151
1165
1166
1176
1168
hem 1148 x 1149
mo.py x 1177
py x
mo
mo.py.fl
mo.py
fl hem py
ks. py. hem fl
1
2
3a
3b
4

Figure 56: Geological map of the contact of the Ackley Granite with the Long Harbour Group, with location of analyses listed in Table 16 and main mineral occurrences. 56a: contact between Schooner Brook and Gisborne Lake. 56b: contact between Rally Pond and Long Harbour.


55°W
Rally Pond
gabbro
Mal Bay Brook
Schooner Brook
58
60
60
4
2
1.2
1
47°45'N
Wylie Hill: 1160, 1161
Motu. 1162, 1163
1158, 1159
1156, 1157
km 0
1
2 km
Long Harbour
55°W
47°45'N

LEGEND

DEVONIAN

- **4** **ACKLEY GRANITE:** *Mainly medium grained, miarolitic, slightly porphyritic, biotite granite; minor, undivided, coarse grained, equigranular biotite granite.*
- **3** **CROSS HILLS GRANITE-DIORITE COMPLEX:** **3a,** *Metagabbro and diabase;* **3b,** *medium grained, biotite-hornblende granodiorite and granite.*

LATE PRECAMBRIAN

- **2** **ANDERSONS COVE FORMATION:** *Unseparated gray, green and minor red, terriganous sediments: includes minor undivided mafic flows.*
- **1** **BELLE BAY FORMATION:** *Predominantly volcanic breccias, ash-flow tuffs, flow layered rhyolite and basalt flows; minor unseparated gabbro.*

BLE 16: CHEMICAL ANALYSES OF SAMPLES COLLECTED FROM THE SOUTHERN CONTACT OF THE ACKLEY GRANITE, MAINLY FROM THE SAGE POND AREA

SAMPLE	221148	221149	221150	221151	221152	221153	221154	221155
ROCK TYPE	GRANITE: FRESH	QUARTZ-HEM. VEIN	GRANITE: FRESH	QUARTZ GREISEN	GRANITE: FRESH	ALTERED GRANITE: GREISEN	GRANITE: FRESH	QUARTZ VEIN
SiO_2 %	77.6	87.6	78.6	85.5	77.7	84.7	76.7	90.5
Al_2O_3	11.85	2.15	11.65	9.90	12.00	8.70	12.55	4.83
Fe_2O_3	0.57	8.33	1.28	0.40	0.98	1.25	0.29	0.06
FeO	0.44	0.12	0.14	0.02	0.13	0.43	0.48	0.21
MgO	0.09	0.05	0.04	0.03	0.12	0.13	0.10	0.04
CaO	0.21	0.10	0.13	0.52	0.30	0.16	0.27	0.19
Na_2O	3.24	0.35	3.55	0.39	3.10	0.44	3.46	1.88
K_2O	4.79	0.88	4.54	0.73	4.78	2.87	4.86	0.60
TiO_2	0.21	0.06	0.13	0.12	0.25	0.24	0.16	0.17
MnO	0.13	0.11	0.03	0.01	0.02	0.20	0.03	0.02
P_2O_5	0.01	0.01	0.01	ND*	0.01	0.01	ND	ND
LOI	0.47	0.39	0.37	1.02	0.55	1.35	0.71	0.40
TOTAL	99.51	100.15	100.47	98.64	99.84	100.28	99.61	98.90
F g/t	645	156	619	9650	1511	2004	874	670
Sn	9	177	23	16	8	221	12	11
W	6.6	41.4	6.4	5.7	5.6	7.4	2.7	6.4
Ba	42	30	42	29	85	89	71	32
Sr	9	7	6	4	13	4	10	3
Rb	476	66	531	90	375	478	403	76
Cr	1	2	2	1	2	1	1	1
V	6	8	3	ND	9	6	ND	3
Cu	2	3	4	5	3	11	7	2
Zn	24	20	14	7	13	47	27	16
Ni	ND	ND	ND	1	ND	ND	ND	1
Ag	0.1	0.2	0.1	ND	0.1	0.2	0.1	ND
Be	9	28	15	4	11	4	10	2
Li	78	28	61	16	49	72	20	36
Mo	2	19	32	12	10	11	3	5
Pb	26	10	16	3	12	9	68	15
Co	2	ND	1	ND	ND	2	ND	ND
Au	-	-	-	-	-	-	-	-
K/Rb	84	111	71	49	106	50	100	65
K/Li	509	261	617	276	810	331	2017	138

* ND not detected

Table 16 (continued):

SAMPLE	221156	221157	221158	221159	221160	221161	221162	221163
ROCK TYPE	GRANITE	QUARTZ VEIN	GRANITE	QUARTZ VEIN	WYLIE HILL: GRANITE contains Mo	WYLIE HILL: GRANITE contains Mo	MOTU: GRANITE: contains Mo	MOTU: GRANITE: contains Mo
SiO_2 %	75.6	96.6	77.2	96.8	81.1	76.3	80.8	81.5
Al_2O_3	12.85	1.03	12.45	1.15	10.30	13.15	11.20	10.35
Fe_2O_3	0.46	0.06	1.10	0.08	0.30	0.61	0.36	0.17
FeO	0.84	0.12	0.02	0.10	0.81	0.50	0.14	0.20
MgO	0.05	0.02	0.07	0.02	0.08	0.16	0.06	0.05
CaO	0.33	0.09	0.25	0.08	0.19	0.19	0.18	0.23
Na_2O	3.81	0.23	3.57	0.29	2.61	2.77	2.83	2.61
K_2O	4.98	0.25	5.27	0.27	4.29	4.07	4.75	4.41
TiO_2	0.11	0.02	0.08	0.01	0.15	0.17	0.15	0.14
MnO	0.05	0.01	0.03	0.01	0.01	0.01	0.02.	0.02
P_2O_5	0.10	0.03	ND	ND	0.02	ND	ND	0.01
LOI	0.63	0.22	0.36	0.16	0.68	01.25	0.52	0.40
TOTAL	99.81	98.68	100.40	98.97	100.54	99.19	101.01	100.19
F g/t	1653	184	80	36	209	1199	235	144
Sn	6	2	2	2	6	30	6	3
W	5.9	1.1	3.5	0.9	9.1	11.6	3.9	20.5
Ba	29	38	32	17	67	55	42	58
Sr	5	1	4	4	15	9	13	10
Rb	409	17	165	17	239	311	310	302
Cr	1	1	2	1	2	2	2	1
V	6	ND	6	3	3	15	6	ND
Cu	2	3	4	3	3	3	6	4
Zn	59	5	37	3	11	21	34	18
Ni	ND	ND	ND	ND	ND	ND	ND	ND
Ag	ND	0.1	ND	ND	0.1	ND	0.1	ND
Be	7	1	6	ND	4	5	5	4
Li	121	21	6	20	12	43	15	17
Mo	3	ND	2	ND	1502	580	35	1937
Pb	30	3	21	2	23	19	19	21
Co	ND	ND	1	ND	ND	1	2	1
Au	-	-	-	-	-	-	-	-
K/Rb	101	122	265	132	149	109	127	121
K/Li	342	99	7290	112	2967	785	2628	2153

Table 16 (continued):

SAMPLE	221165	221166	221168	221170	221171
ROCK TYPE	QUARTZ GREISEN: TRACE Mo	QUARTZ GREISEN: TRACE Mo	ALTERED GRANITE: GREISEN	ALTERED GRANITE: GREISEN	QUARTZ GREISEN
SiO_2%	80.0	90.7	78.1	81.2	75.7
Al_2O_3	11.75	3.84	11.55	10.3	18.45
Fe_2O_3	3.48**	0.20	2.02	0.25	0.99
FeO	***	0.41	0.94	0.13	0.49
MgO	0.03	0.04	0.12	0.04	0.04
CaO	0.12	2.49	0.78	3.80	0.36
Na_2O	0.02	0.06	0.09	0.05	0.05
K_2O	0.05	0.34	3.85	0.34	0.25
TiO_2	0.28	0.14	0.10	0.25	0.26
MnO	0.02	0.02	0.44	0.02	0.02
P_2O_5	0.02	0.03	0.01	0.02	0.01
LOI	2.57	2.00	2.24	2.96	0.95
TOTAL	98.34	100.27	100.24	99.36	97.57
F g/t	7063	14,090	5275	18,350	9900
Sn	1175	313	31	5	9
W	3.4	7.0	12.5	7.6	5.3
Ba	17	25	22	8	4
Sr	2	12	9	11	7
Rb	2	35	958	52	39
Cr	1	1	1	1	1
V	ND	3	6	9	3
Cu	10	8	10	21	13
Zn	24	8	95	7	19
Ni	ND	ND	ND	ND	ND
Ag	0.4	ND	0.3	0.2	ND
Be	1	1	71	21	1
Li	6	3	104	77	39
Mo	106	4540	45	13	58
Pb	12	10	23	77	6
Co	1	1	ND	6	ND
Au	ND	ND	-	-	ND
K/Rb	208	81	33	54	53
K/Li	69	941	307	36	53

** total iron as Fe_2O_3

*** not determined

Table 16 (continued):

SAMPLE	221172	221173	221175	221176	221177
	QUARTZ GREISEN	QUARTZ GREISEN	ALTERED GRANITE: GREISEN	GRANITE: FRESH	QUARTZ GREISEN
SiO_2 %	82.8	86.1	84.2	78.6	90.0
Al_2O_3	12.25	11.75	9.85	12.3	7.25
Fe_2O_3	0.44	0.01	0.18	0.47	0.92
FeO	0.18	0.20	0.15	0.19	0.04
MgO	0.14	0.02	0.03	0.04	0.03
CaO	0.49	0.13	2.46	0.19	0.10
Na_2O	0.03	0.04	0.03	2.64	0.04
K_2O	0.59	0.31	0.32	4.65	0.50
TiO_2	0.17	0.15	0.24	0.20	0.16
MnO	0.02	0.03	0.02	0.04	0.02
P_2O_5	0.01	0.01	0.02	0.01	0.01
LOI	1.26	0.85	2.17	0.53	0.80
TOTAL	98.38	99.61	99.67	100.86	99.87
F g/t	6268	9140	11,820	925	5898
Sn	103	18	7	15	216
W	6.4	3.3	20.5	8.0	10.4
Ba	11	ND	100	36	4
Sr	4	4	7	5	2
Rb	134	55	49	638	68
Cr	6	ND	3	ND	ND
V	6	ND	3	ND	ND
Cu	5	10	9	3	10
Zn	11	12	7	13	10
Ni	ND	ND	ND	ND	ND
Ag	ND	ND	0.2	ND	0.2
Be	ND	ND	2	6	1
Li	82	28	21	69	10
Mo	4	2	7	3	36
Pb	2	3	7	13	21
Co	ND	1	1	ND	ND
Au	-	-	-	-	-
K/Rb	36	47	54	60	61
K/Li	60	92	126	559	415

Be (28 g/t), compared to the host granite (sample 221148). No cassiterite or W minerals were found in thin section, although the highly anomalous Sn value indicates that Sn mineralization is probably present. The common association of specularite veins with cassiterite-bearing topazite provides a readily usable prospecting aid. The W value from the quartz-hematite vein is the highest obtained in the Ackley Granite. Examination of the vein under UV light did not indicate the presence of scheelite.

Topazite greisens are locally abundant between locality 221177 (2 km east of Sage Pond) and Anesty Hill. The topazite greisen veins may extend up to 2 km into the granite from the contact. The topazite is saccharoidal, white-weathering, and pink to orange on fresh surfaces. The veins form prominent, generally smooth, rounded ridges, up to 40 m in length and 10 m in width, which are aligned roughly parallel to the granite contact. The mineralogy of the topazite greisens is dominated by quartz which forms fine grained, interlocking aggregates with topaz. Round quartz phenocrysts are also common in some of the topazites and may be residual phenocrysts from the parent aplite or fine grained granite. Feldspars are virtually absent. Fine grained topaz is a prominent accessory and is readily distinguished from quartz, in thin section, by its relief and well developed, parallel cleavage. Topaz may form up to 10% of the mode. Other accessories, present in highly variable proportions, are fluorite, sericite, kaolinite(?), molybdenite, cassiterite, pyrite, hematite and sphene. Fluorite is common and occurs as an interstitial mineral. Sericite varies in abundance from less than 1% to more than 10% and is clearly a replacement of feldspar. Kaolinite(?), seen in thin section, occurs as aggregates of fine grained platelets, and is a replacement of feldspar. Kaolin(?) is locally more abundant than sericite. Molybdenite commonly forms 2-3 mm flakes, but is usually present only in small amounts, although sample from a large pyrite-rich topazite greisen (sample 112266) from the north end of Deer Pond, which contained molybdenite, analyzed 4,540 g/t Mo. This, however, is abnormally high. Cassiterite has been found in three thin sections of topazite greisen veins. The cassiterite shows characteristic zoning and occurs as an interstitial mineral. Pyrite varies greatly in abundance, in the topazites, from trace amounts to over 5% (samples 221165, 221177). Pyrite occurs as finely disseminated crystals which weather to form a 1 cm thick rusty gossan on some of the topazite greisens. At locality 221177 and 1.5 km to the southwest, the pyrite occurs as variably altered blebs 5 mm diameter, which have been partially weathered out to form a sponge-like rock. Specularite locally occurs as isolated crystals and 1-3 mm thick veinlets which cut the topazite greisens. Sphene is rare and occurs as altered, anhedral, interstitial crystals.

The predominance of quartz and topaz in the topazite greisens is clearly reflected in the major element chemistry of samples 221151, 221165, 221166, 221171, 221172, 221173, and 221177. Over 90% of the major element's total is comprised of SiO_2 and Al_2O_3 and reaches over 97% of the total in analysis 221173. Topaz has a relatively low SiO_2 content and is rich in Al_2O_3 and F (Table 17). The very low alkali content of the topazite greisens reflects the absence of feldspar and the low sericite content. Thus the higher Al_2O_3 values in the greisens reflect a higher proportion of topaz in the topazite greisens. Minor amounts of possible kaolinite are present and this would also contribute to the high Al_2O_3 content of the rocks. The high F content of topaz is partly reflected in the high F values in the topazite greisens, although part of the F content is related to the trace amounts of fluorite in the rock. Strontium, Rb, and Ba are strongly depleted in the topazite greisens.

TABLE 17: ANALYSIS OF TOPAZ FROM TOPAZ-QUARTZ ROCKS (TOPAZITE), CORNWALL

(from Deer, Howie and Zussman, 1969)

oxide	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	F	H_2O^+	H_2O	O≡F	Total
wt%	31.94	55.80	0.32	0.07	0.07	0.13	17.24	1.57	0.03	7.27	99.91

Lithium concentrations are variable and range from 3 g/t to 82 g/t, with the higher Li values being found generally in the topazite greisens with higher than average K_2O values. Nevertheless, the K/Li ratio is lower in topazite greisens with the higher Li values. The K/Li ratio is generally much lower in the topazite greisens than in the host granite, *e.g.* the K/Li ratio in granite sample (221175) is 559, and in the topazite greisen (sample 112265), which cuts the granite, the K/Li ratio is 69. This indicates Li enrichment.

Tin is present in extremely variable concentrations in the topazite greisens, with values ranging from 9 to 1175 g/t, even within a single topazite greisen sheet. For example, samples 221165 and 221166 were taken, about 30 m apart, from a large topazite greisen sheet near Deer Pond. Sample 221165, which is rich in pyrite, contains 1175 g/t Sn and sample 221166, which contains a few flakes of molybdenite and minor pyrite, contains 313 g/t Sn. This indicates that Sn mineralization is variably developed in the topazite greisens.

Tungsten is present in very minor amounts in the topazite greisens with no enrichment compared to the host granite.

Molybdenite occurs in trace amounts in the topazite greisens with only small pockets of higher grade mineralization. The highest Mo values are from samples taken from topazite greisens southeast of Anesty Hill. The topazite greisens, from north of Anesty Hill, have generally lower Mo values. The Mo analysis of sample 221166 should not be taken as typical as the sample was selected, because of the presence of molybdenite, to ascertain if it was enriched in other economic elements, such as Sn or W. Samples 221165, 221166, and 112277 were assayed for Au but none was detected.

Two occurrences of gray, highly altered granite were discovered east and south of Anesty Hill. These occurrences are considered to be greisens. The greisens are gray and form linear zones with a narrow gradational zone within the host pink fine grained aplitic granite. On weathered surfaces, quartz is conspicuous as raised 2 to 3 mm anhedral crystals in a recessed gray-green, very fine grained matrix. Scattered 2 mm wide, pale biotite flakes are also prominent in hand specimen. In thin section, anhedral, 2 to 5 mm diameter, anhedral quartz crystals are prominent. These are clearly relict igneous crystals. The feldspars have been completely replaced by very fine grained sericite which forms an interlocking mosaic. Biotite shows various stages of replacement by coarse muscovite, and this muscovite is partly replaced by fine sericite. Fine grained, quartz mosaics occur as 1 mm clots and very narrow veinlets, and indicate secondary silicification of the gray greisen. Magnetite forms 0.1 mm, euhedral to anhedral crystals, which are variably altered to hematite. Other accessories, found in some hand specimens include fine grained, purple fluorite, and 5 mm wide bands of red hematite. Topaz was not seen in thin section.

Two gray greisens have been analyzed. Samples 221153, 221170 and 221175 are from the same gray greisen vein, which is located near the southwest end of Sage Pond. Sample 221168 is from a greisen, which is located 200 m north of Deer Pond, close to topazite greisen veins. A comparison of the chemistry of the gray greisens with that of the host fresh granite samples (analyses 221152 and 221176, respectively) indicates a moderate increase in SiO_2 from about 78% to a maximum of 84% with some increase in Fe, in some gray greisen analyses, and a strong increase in L.O.I.. In analysis 221168 and 221175, there is an apparent increase in CaO. This is clearly related to introduced fluorite, which is indicated by the very high F contents of these samples.

The gray greisens are strongly depleted in other major elements. Soda is strongly depleted and has clearly been preferentially removed compared to K_2O. The proportion of K_2O which has been removed is highly variable, and ranges from about 40% to over 90% in one gray greisen sheet. In the other gray greisen sheet (221168), only about 20% of the K_2O has been extracted whereas virtually all of the Na_2O has been removed. In the gray greisens with low K_2O values, there is evidence of a higher degree of silicification and, therefore, a lower proportion of sericite.

Trace element concentrations indicate a pronounced increase in F which clearly reflects the presence of fluorite. Tin is variably enriched with a maximum value of 221 g/t, but within the same gray greisen vein another sample contains only 7 g/t. This may reflect either a zonal concentration of tin mineralization or discrete pockets. Similarly, Rb and Li show highly variable concentrations within the same gray greisen vein, but Li is generally enriched in both gray greisen veins. K/Li ratios indicate that compared to Li, K is preferentially removed. Tungsten is variably enriched, with a maximum concentration of 20 g/t, compared to about 8 g/t in fresh granite. Molybdenum shows only minor enrichment.

The gray greisens are chemically intermediate between the granite and the topazite greisens. The topazite greisens are richer in silica and more strongly depleted in the alkalies Na, K, Rb, and Li. The proportion of sericite is lower and topaz is more abundant in the topazite greisens. Textural features, such as anhedral quartz phenocrysts in the topazite greisens, clearly indicate an igneous parentage. Thus the gray greisens may represent a less evolved stage of alteration of the granite than the topazite greisens.

Strong similarities exist between the various greisened rocks of southern Ackley Granite and the Cornwall Sn deposits. Varlamoff (1978) and Edmonds *et al.* (1975) have briefly described the main features of the Cornwall Sn deposits and there are several striking similarities and also a few differences.

The mineralogy of the greisened rocks is similar with topaz, fluorite, hematite, pyrite, and cassiterite common to both areas. The high level emplacement of the two granites is also similar. Both granites are postorogenic although the Ackley Granite is possibly 80 Ma older than the Cornwall granites and follows a different orogenic event.

Major differences include the apparent lack of extensive tourmalinization and the apparent absence of spatially associated base metal sulfides within the Ackley Granite and the country rocks. Kaolinization, which is well developed in the Cornwall granites, is not widespread in the Ackley Granite and appears to be restricted to the greisens. Minor base metal mineralization occurs within the Precambrian volcanics, south of the Ackley Granite, but the relationship of the base metal mineralization to the granite has not been ascertained. Wolframite mineralization is locally well developed in the Cornwall granites but has not been found within the Ackley Granite, although some anomalous values have been recorded (see Table 14).

The lack of base metal mineralization may be related to the nature of the country rocks to the south of the Ackley Granite, which have possibly prevented the formation of a hydrothermal system. The Cornwall granites have cut various Carboniferous clastic and calcareous sediments, which are probably more permeable than the metamorphosed Precambrian volcanics and clastic sediments which occur at the Ackley Granite contact. The Carboniferous sediments in Cornwall are possibly a better source of base metals than the Precambrian acid volcanics and associated epiclastics.

There are some similarities between the Ackley Granite Sn prospects and the East Kemptville Sn-U occurrences in Nova Scotia. The host granitoids have a similar Middle Devonian age. The mineralization commonly occurs close to the granite contact, in highly differentiated phases. The South Mountain Batholith, which hosts the East Kemptville occurrences, has a great variety of granitoid units, and is generally more mafic than the Ackley Granite. A prominent feature of the South Mountain Batholith is the presence, locally, of garnet, andalusite and cordierite within the phases, which emphasizes the highly corundum-normative chemistry of the batholith (McKenzie and Clarke, 1975; Allen and Clarke, 1981). The Ackley Granite is generally corundum normative but does not contain garnet, andalusite, or cordierite, and most of the batholith does not contain muscovite. The South Mountain Batholith is clearly an S-type granite, whereas the Ackley Granite is I-type (Table 18) (Chappell and White, 1974). Another feature of the chemistry of the mineralized areas of the South Mountain Batholith is the enrichment of Na_2O and P_2O_5 (Chatterjee, 1980) in the mineralized areas. Clearly these features are not present in the mineralized areas of the Ackley Granite. The South Mountain Batholith Sn mineralization also has associated Be, W and U mineralization, a feature which is not seen in the Ackley Granite.

TABLE 18: MEAN I-S RATIOS [Al_2O_3/ (Na_2O+K_2O+CaO) in mol. wt. %)] FOR EACH UNIT OF THE ACKLEY GRANITE

Unit	Mean	Max	Min	S.D.
9	1.04	1.15	0.84	0.059
10	1.05	1.11	0.93	0.046
11	1.08	1.17	1.00	0.041
12	1.04	1.24	0.98	0.062
13	1.03	1.09	0.97	0.022
14	1.04	1.10	0.98	0.022
15	1.05	1.22	1.00	0.042

PETROGENESIS OF THE ACKLEY GRANITE

A ternary plot of $Na_2O + K_2O$: $FeO_{(total)}$: MgO (AFM) for the seven units of the Ackley Granite is given in Figure 57. A reference line, based on the distribution of values in Unit 10, has been drawn on each triangle. This line has no petrogenetic significance. The AFM diagrams further illustrate the difference between Units 9-12 and Units 13-15. Two main observations can be made. Units 9-12 generally plot along the reference line, whereas Units 13-15 plot on the A-F side of the line. This suggests that the northern and southern units evolved along separate paths. The northern units show a wide range in composition with a generally even distribution of points for each unit. The southern units have a restricted range of values and tend to concentrate within a narrow field near the Na_2O + K_2O corner of Figure 57.

A comparison of the differentiation trend for the northern units with the trend of part of the calc-alkaline

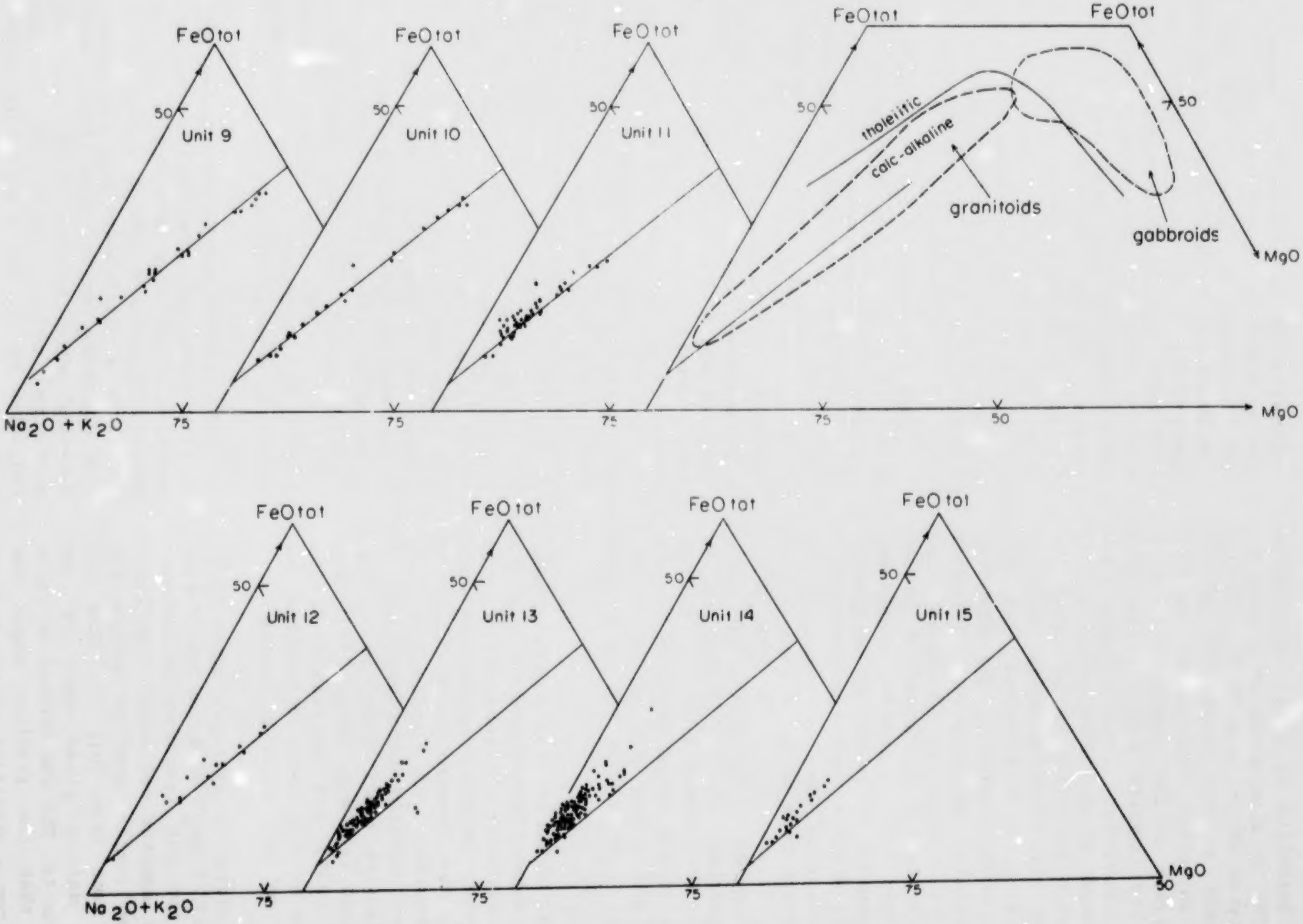


Figure 57: AFM diagrams ($Na_2O + K_2O$: total iron as FeO : MgO, all weight %) for Units 9 through 15 of the Ackley Granite. Straight line in each triangle is estimated best fit from Unit 10. Fields outlined by dashes are from Atherton et al. (1979). Curved solid line is tholeiitic - calc-alkaline boundary from Irvine and Baragar (1971).

Coastal Batholith of Peru (Atherton *et al.*, 1979) is also given in Figure 56. The analyses of Units 9-12 fall in the same field as the granitoids of the Coastal Batholith. Only about half of the analyses of the southern units of the Ackley Granite fall within this field, however, and these are concentrated at the alkali-rich end of the Coastal Batholith trend. Thus the trend for the northern units could be described as calc-alkaline, but the southern units clearly do not show any calc-alkaline affinities. A major difference, however, between the northern units and the Coastal Batholith of Peru and other batholith complexes, is the absence of gabbro or diorite in the Ackley Granite; only the Cross Hills Granite-Diorite Complex contains any sizable proportion of mafic rocks. It is possible, however, that the Cross Hills Complex may not be Devonian, but could be Precambrian, as it is cut by an abundance of diabase dikes, a feature not found in the other Devonian plutons in the Gander and Avalon Zones but common in the Precambrian granitoid rocks.

A calc-alkaline trend would also imply a subduction-related origin for the granitoids. Subduction in Newfoundland, however, appears to have ceased by the Caradoc as evidenced by the cessation of volcanism and subsequent widespread deposition of graptolite-rich black shale in central Newfoundland (see *e.g.* Dean, 1978; Kean *et al.*, 1981) and extensive flysch deposition in the Upper Ordovician and Silurian, and only minor volcanism.

The initial Sr isotopic ratio (Bell *et al.*, 1977) is 0.7048 for the Ackley Granite and the isochron is defined mainly by samples collected from Units 13-15. One sample used to define the isochron came from Unit 11. Thus the isochron mainly gives data on the southern units. The low initial Sr ratio suggests that the granitic magma was derived from a primitive source such as the lower crust. The generally high concentration of lithophile elements in the southern units *e.g.* Li, Rb, U, K, and Zn favors an upper crustal origin for Units 13-15. The remarkable chemical homogeneity of the southern units (apart from local variations in trace elements) clearly suggests extensive widespread partial melting of crustal rocks with a similar chemistry. The northern units of the Ackley Granite, which show a wider range of composition, were probably derived from crustal rocks but with a greater degree of partial melting to produce the more basic compositions.

Whalen (1980) has indicated that the granites around the Rencontre Lake molybdenite occurrences crystallized near the ternary minimum of the system SiO_2 - $NaAlSi_3O_8$ - $KAlSi_3O_8$, between 1 kbar and 0.5 kbars pH_2O. This is supported by the widespread occurrence of granophyre, tuffisite and miarolitic cavities which are consistent with high level emplacement. A plot of the normative Qz:Ab:Or data for Units 13, 14, and 15 shows a pattern similar to the Rencontre Lake data (Figure 58). Furthermore, the widespread occurrence of miarolitic cavities and granophyre in Units 13-15 supports emplacement of these units at a high level in the crust. High level emplacement of a magma would also require the magma to be undersaturated in H_2O. The scarcity of pegmatites throughout the southern units, and the more common occurrence of miarolitic cavities and tuffisite in aplites rather than the host granite indicates that the magma became saturated in water during the late stages of crystallization.

The northern units lack any features of very high level granites. Granophyre, miarolitic cavities and tuffisite are absent. Pegmatites are also rare which indicates a water-undersaturated magma. The northern units, therefore, were intruded at a greater depth than the southern units. This is further indicated by the 500 m wide cordierite-bearing metamorphic aureole, which is extensively developed along the contact

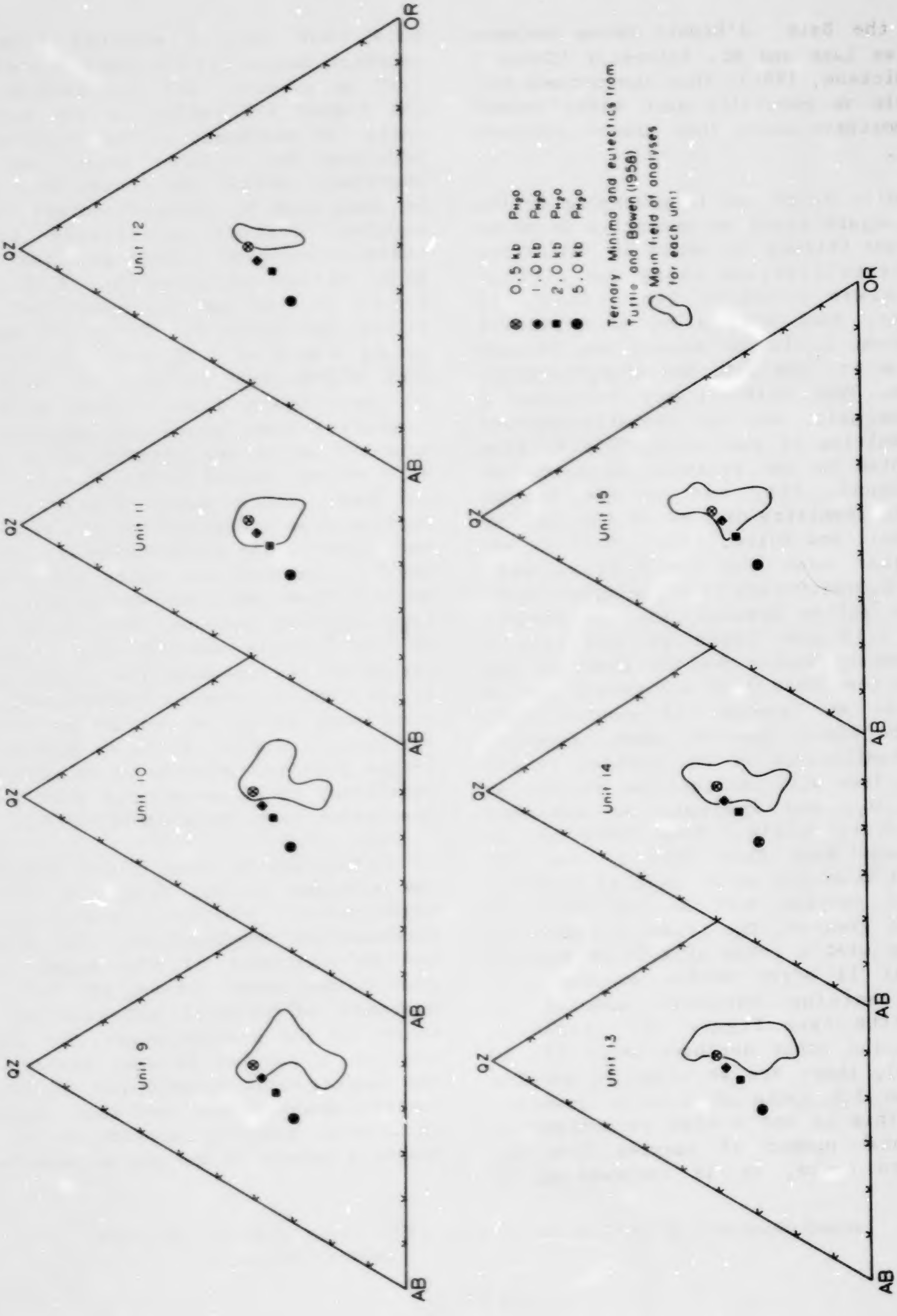


***Figure 58:** Normative proportions of QZ:OR:AB (quartz:orthoclase:albite, all weight %) for each unit of the Ackley Granite.*

with the Baie d'Espoir Group between Jubilee Lake and Mt. Sylvester (Swinden and Dickson, 1981). Thus the metamorphic aureole is generally much wider around the northern units than around southern units.

Units 9, 10 and 12 generally define an elongate trend on normative Qz:Ab:An diagrams (Figure 58) which is indicative of crystallization along the albite-orthoclase cotectic line. Unit 11, however, does not follow this pattern but forms a cluster around the ternary minimum in the $SiO_2:NaAlSi_3O_8:KAlSi_3O_8$ system. Thus Unit 11 may represent a minimum melt, and was probably derived from melting of sediments. This is also indicated by the presence of muscovite in subunit 11b, and by the S-type granite chemistry of some of the samples (Chappell and White, 1974). Unit 11 has a higher mean I-S ratio (*i.e.* mol. Al_2O_3/K_2O+Na_2O+CaO) than the other units of the Ackley Granite. (Values greater than 1.10 are taken to indicate a sedimentary source for the granites and values less than 1.10 are considered to indicate an igneous (I) source. Care must be taken, however, when assessing the significance of the ratios, as any alkali loss will increase the proportion of Al_2O_3, and indicate an apparent sedimentary origin.) From Table 18, it can been seen that Unit 11 has the highest mean I-S ratio. Unit 11 contains several samples with an I-S ratio of 1.10 or greater. The greatest number of samples with a ratio of 1.10 or greater in Unit 11 occur within subunit 11b, whch contains variable amounts of muscovite (see Figure 59), although within the other northern units (9, 10 and 12), there are at least 10 samples with an I-S ratio of 1.10 or greater. While this is not a high percentage of the total number of samples from the northern units, it is interesting to note that only 2 samples from the southern units (13-15) have a ratio of 1.10 or greater. All the samples with the higher I-S ratios in the northern units lie northwest of the trace of the Hermitage Bay - Dover fault, and are, therefore, within the Gander Zone which is dominated by metasedimentary rocks. Another feature considered to be characteristic of S-type granites is an Na_2O content of less than 3.2%. From Figure 44, it can be seen that Na_2O values for Units 9, 10 and 12 scatter around a mean of 3.2%, but Unit 11 has a much higher average at 3.6%. Thus the northern units display some affinity towards S-type granites, whereas the southern units are clearly I-type with Na_2O values around 3.71. Therefore the northern units have probably been derived from a combination of melts from both igneous and metasedimentary sources whereas the southern units are derived mainly from an igneous source. The contradiction between the low initial Sr^{87}/Sr^{86} ratio and the high concentration of the incompatible elements (U, K, Li, *etc.*) remains unresolved. The occurrence of Mo in the Ackley Granite was used by Whalen (1980) to indicate an I-type granite, whereas Sn is generally considered to be associated with S-type granitoids (*e.g.* Beckinsale, 1979).

Strong and Dickson (1978) discussed the problems of the origin of similar megacrystic biotite granites in northeastern Newfoundland. The high K and Rb contents of the megacrystic granitoids were taken to indicate anatexis of crustal material as the source of the granite magma. The Ackley Granite is similar in many respects to the megacrystic granitoids of northeastern Newfoundland and thus anatexis of crustal material appears to be the probable source of the Ackley Granite.

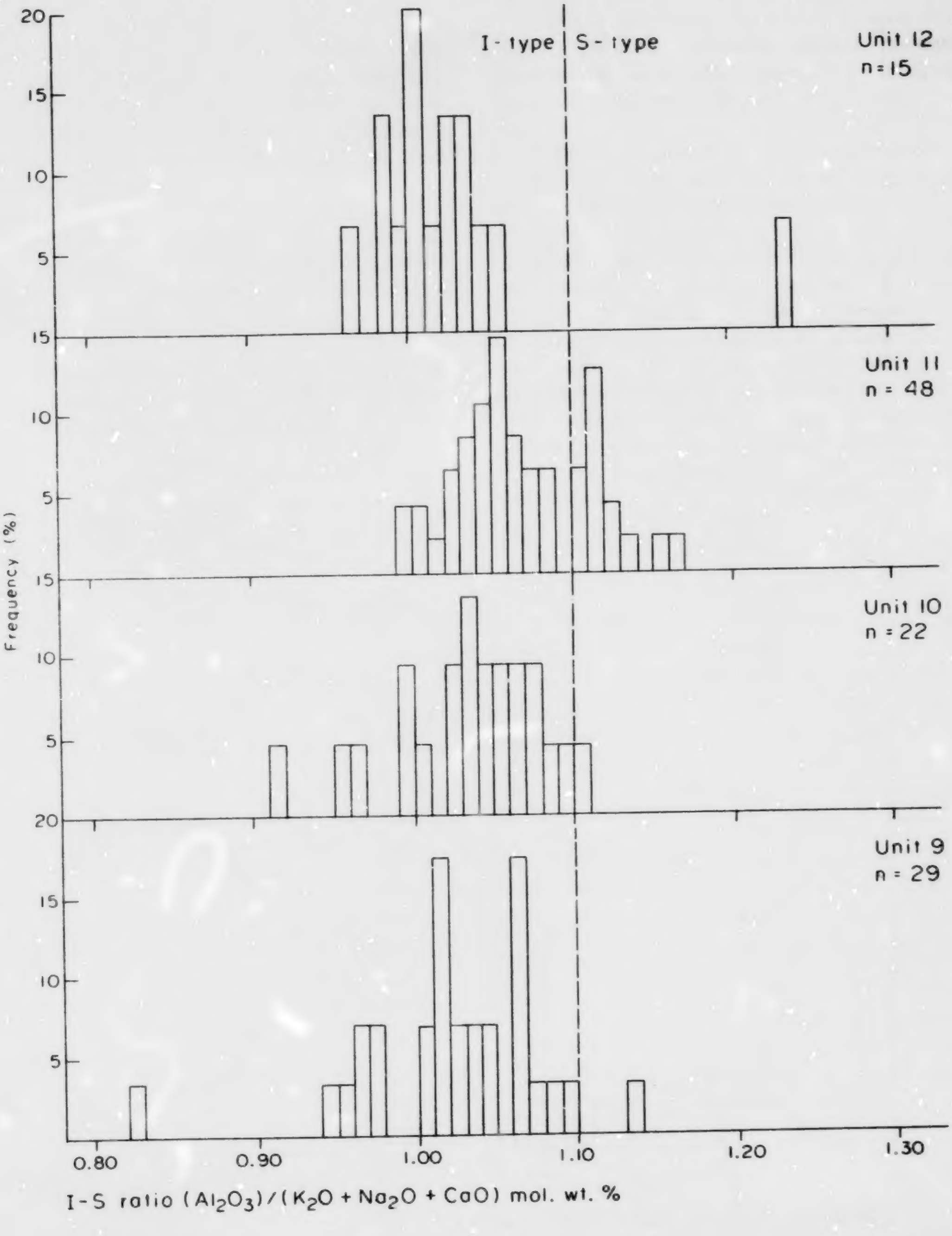


Figure 59a: ***Frequency diagram of I-S ratios for Units 9, 10, 11 and 12 of the Ackley Granite. n = number of analyses.***

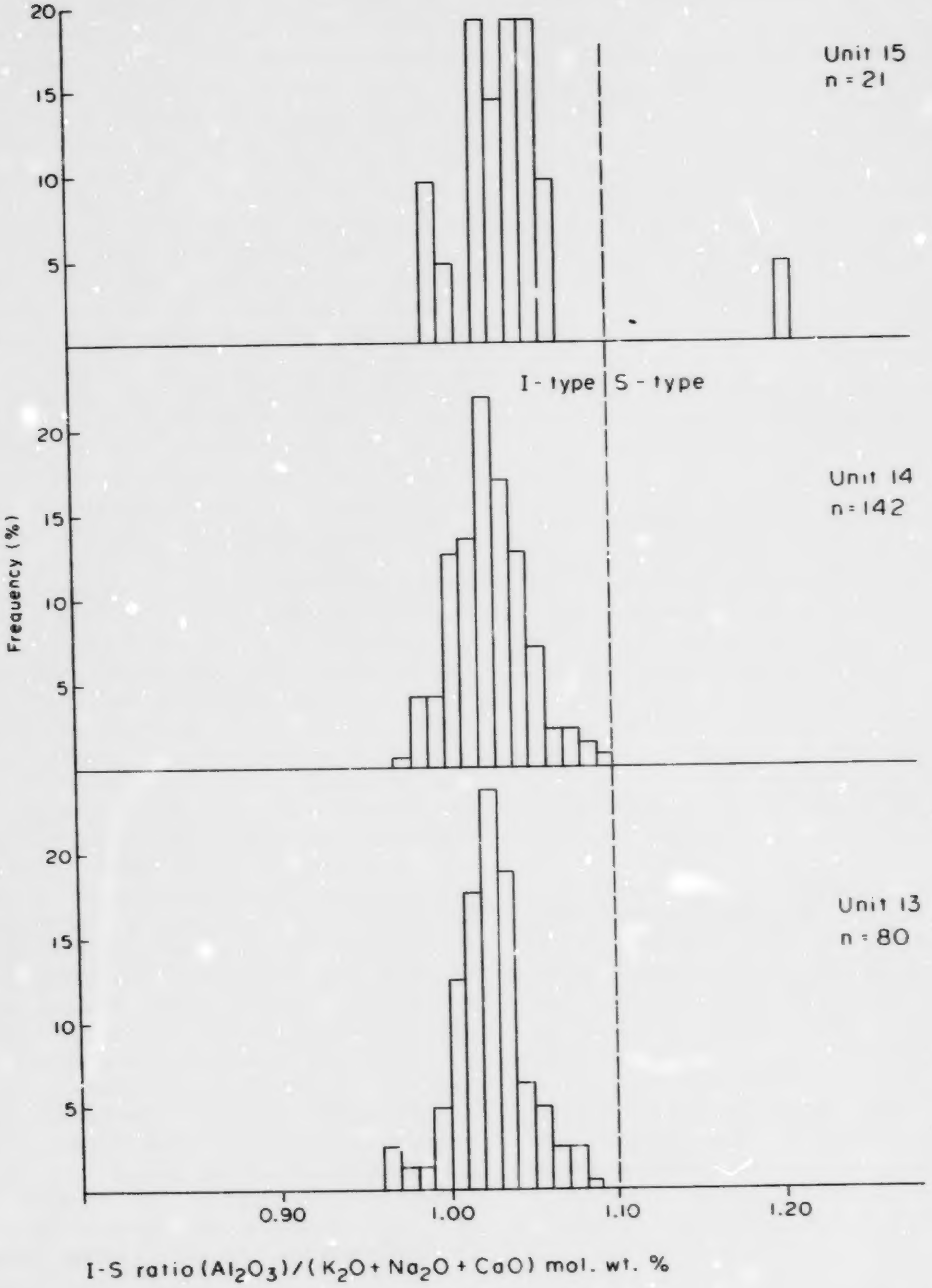


Figure 59b: Frequency diagram of I-S ratios for Units 13, 14 and 15 of the Ackley Granite.

ACKNOWLEDGEMENTS

The 1979 sampling program was carried out with the assistance of Ray Talkington, Peter Elias and Conrad Clarke. Sean O'Brien, Ges Nunn and Barry Wheaton assisted during the final stages of sampling.

Paul Delaney assisted ably during detailed mapping of the southern Ackley Granite contact, and also point-counted the thin sections.

The cooperation of David Press, of Memorial University, and the expertise of Hank Wagenbauer, Charles Reilly and Herb Skanes of the Mines Branch, in carrying out the chemical analyses is greatly appreciated.

Michael Mackey performed most of the computer work and educated the author in the wonders of computers.

Discussions of the geology and geochemistry of the Ackley Granite with Sean O'Brien, Ges Nunn, Steve Colman-Sadd, Frank Blackwood, Scott Swinden, Cyril O'Driscoll, Peter Davenport, Paul Dean and Ron Smyth of the Mines Branch, John O'Sullivan of Esso Minerals, J.B. Whalen of the G.S.C., and David F. Strong of Memorial University were most helpful.

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APPENDIX I

Analytical Methods

Major elements, including FeO and Fe_2O_3, loss on ignition, F, Li, U, and Mo have been determined on all samples. All but 16 samples have been analyzed for V, Cr, Ni, Cu, Zn, Ga, Rb, Sr, Y, Zr, Nb, Ba, La, Ce, Pb, Th, and U. All samples from the Ackley Granite have been analyzed for Sn. Selected samples have been analyzed for W. Major elements, Li, Mo, total Fe as Fe_2O_3, and Sn were determined by AA; FeO was determined by titration; U was determined by neutron activation and XRF; F by ion-selective electrode; other trace elements by XRF; and loss on ignition by heating samples to 1100°C in a muffle furnece for 2 hours and measuring weight loss.

Detection limits (XRF) and precision

Detection limits for XRF analysis are given in Table A1.

Precision has been determined for all elements using pairs of analytical splits. Precision (P) for each pair was calculated using the formula:

$$P = \frac{(V_1 - V_2)}{V_{1,2}} \times 100,$$

where V_1 = first value, V_2 = second value, $V_{1,2}$ = mean of $V_{1,2}$ $V_1 + V_2$.

The mean precision for the pairs was then determined. The mean precision and standard deviation are given in Table A2.

The apparently poor precision shown by some elements is caused by the low concentration of some of the oxides and elements such as MnO, P_2O_5, Cr, Ni, Cu, Zn, Ga, Mo, and Sr. If a pair of samples analyze 3 and 4 ppm Mo then the precision is an apparently poor 28.57%. Thus the absolute values for each pair should be considered.

Accuracy

An estimate of accuracy of the determinations for the various oxides and elements using international standards is given in Tables A3 a-m, A4 a-e, and A5 a and b. No estimation of accuracy for Sn or W is available.

TABLE A-1: DETECTION LIMITS FOR TRACE ELEMENTS BY X.R.F. AT MEMORIAL UNIVERSITY OF NEWFOUNDLAND

Element	Detection Limit (g/t)	Value on list of analyses (Appendix II) Less than Detection Limit
Ba	20	10
Cr	10	5
V	10	5
La	10	5
Ce	10	5
Cu	5	2
Ni	5	2
Zn	5	2
Ga	5	2
Rb	2	1
Sr	2	1
Y	2	1
Zr	2	1
Nb	2	1
U	2	1
Th	2	1
Pb	5	2

TABLE A-2: PRECISION OF ANALYTICAL METHODS

a. Major elements, analyzed by
Newfoundland Mines and Energy

Element	P	S.D. of difference	No. of pairs
SiO_2	0.93	0.89	40
Al_2O_3	1.25	1.80	40
Fe_2O_3	39.91	43.42	37
FeO	9.66	16.48	37
FeO_{total}	5.54	12.15	40
MgO	8.74	8.81	40
CaO	6.34	9.25	40
Na_2O	1.54	2.95	40
K_2O	1.36	1.30	40
TiO_2	9.02	10.74	40
MnO	8.38	11.73	40
P_2O_5	12.03	22.33	40
LOI	6.54	7.06	40

b. Trace elements analyzed by
Memorial University of Newfoundland,
Newfoundland Mines and Energy,
and X-ray Assay Laboratories, Toronto.

Trace Elements	P	S.D. of difference	No. of pairs
Li+	5.74	6.49	34
F+	14.33	12.79	34
V	5.77	9.79	33
Cr	13.82	31.34	33
Ni	13.81	19.70	33
Cu	10.46	29.37	33
Zn	16.64	32.82	33
Ga	18.89	35.25	33
Rb	1.46	1.57	33
Sr	3.59	7.25	33
Y	8.51	11.37	33
Zr	4.89	7.22	33
Nb	6.61	9.57	33
Mo+	23.28	24.40	34
Sn+	17.22	22.35	6
Ba	9.74	19.11	33
La	14.39	20.90	33
Ce	10.12	15.77	33
Pb	10.01	16.74	33
Th	9.85	12.43	33
U NA*	4.85	3.88	29

+ Mines and Energy

* U by neutron activation

** U by x-ray fluorescence

TABLE A-3: ACCURACY OF MAJOR ELEMENT DETERMINATIONS

P_2O_5 by titration; the rest by A.A.
Newfoundland Department of Mines and Energy.

Notes: X: mean of determinations
S: standard deviation
n: number of determinations
max: maximum value obtained
min: minimum value obtained

a. STANDARD: AGV-1

	Abbey (1980)	Mines & Energy				
OXIDE	Usable Value	X	S	n	max	min
SiO_2	59.61	58.96	0.32	3	59.2	58.6
Al_2O_3	17.19	17.22	0.19	3	17.35	17.0
Fe_2O_3(total)	6.78	6.79	0.07	3	6.84	6.71
MgO	1.52	1.53	0.01	3	1.54	1.52
CaO	4.94	4.81	0.07	3	4.85	4.73
Na_2O	4.32	4.22	0.06	3	4.26	4.16
K_2O	2.92	3.01	0.10	3	3.12	2.94
TiO_2	1.06	1.11	0.03	3	1.14	1.08
MnO	0.10	0.10	0.01	3	0.10	0.09
P_2O_5	0.51	0.48	0.05	3	0.53	0.43

b. STANDARD: BCR-1

	Abbey (1980)	Mines & Energy				
OXIDE	Usable Value	X	S	n	max	min
SiO_2	54.53	54.1	0.29	4	54.4	53.7
Al_2O_3	13.72	13.54	0.15	4	13.75	13.40
Fe_2O_3(total)	13.41	13.51	0.08	4	13.61	13.42
MgO	3.48	3.52	0.04	4	3.56	3.48
CaO	6.97	6.94	0.02	4	6.96	6.91
Na_2O	3.30	3.24	0.02	4	3.26	3.21
K_2O	1.70	1.73	0.04	4	1.77	1.67
TiO_2	2.26	2.49	0.08	4	2.57	2.38
MnO	0.18	0.19	0.01	4	0.19	0.18
P_2O_5	0.36	0.34	0.02	4	0.36	0.32

TABLE A-3 (continued):

c. STANDARD: BdVO-1

OXIDE	Abbey (1980) Usable Value	Mines & Energy X	S	n	max	min
SiO_2	49.9?	50.1	0.76	4	50.8	49.0
Al_2O_3	13.7?	13.93	0.10	4	14.05	13.80
Fe_2O_3(total)	12.0?	12.40	0.16	4	12.59	12.23
MgO	7.2?	7.37	0.05	4	7.43	7.33
CaO	11.40?	11.23	0.32	4	11.46	10.79
Na_2O	2.3?	2.17	0.02	4	2.18	2.15
K_2O	0.53?	0.49	0.02	4	0.52	0.50
TiO_2	2.7?	3.03	0.14	4	3.24	2.93
MnO	0.17?	0.18	0.01	4	0.18	0.17
P_2O_5	0.28?	0.25	0.03	4	0.29	0.21

d. STANDARD: G-2

OXIDE	Abbey (1980) Usable Value	Mines & Energy X	S	n	max	min
SiO_2	69.22	68.4	0.62	4	69.1	67.6
Al_2O_3	15.40	15.25	0.11	4	15.40	15.15
Fe_2O_3(total)	2.69	2.54	0.03	4	2.58	2.50
MgO	0.75	0.76	[illegible]02	4	0.78	0.74
CaO	1.96	1.92	[illegible]5	4	1.96	1.84
Na_2O	4.06	4.12	0.04	4	4.16	4.07
K_2O	4.46	4.59	0.07	4	4.68	4.51
TiO_2	0.48	0.48	0.01	4	0.48	0.47
MnO	0.03	0.03	0	4	0.03	0.03
P_2O_5	0.13	0.12	0.01	4	0.13	0.10

e. STANDARD: GSP-1

OXIDE	Abbey (1980) Usable Value	Mines & Energy X	S	n	max	min
SiO_2	67.32	66.8	0.88	4	68.0	65.9
Al_2O_3	15.28	14.9	0.20	4	15.20	14.75
Fe_2O_3(total)	4.30	4.20	0.02	4	4.23	4.18
MgO	0.97	0.97	0.01	4	0.99	0.96
CaO	2.03	2.01	0.03	4	2.05	1.99
Na_2O	2.81	2.84	0.03	4	2.87	2.80
K_2O	5.51	5.63	0.09	4	5.73	5.54
TiO_2	0.66	0.68	0.04	4	0.71	0.63
MnO	0.04	0.04	0.01	4	0.04	0.03
P_2O_5	0.28	0.28	0.03	4	0.31	0.24

TABLE A-3 (continued):

f. STANDARD: MAG-1

OXIDE	Aboey (1980) Usable Value	Mines & Energy X	S	n	max	min
SiO_2	50.9?	49.25	0.07	2	49.3	49.2
Al_2O_3	16.4?	15.9	0.07	2	15.95	15.85
Fe_2O_3(total)	6.80?	6.76	0.01	2	6.76	6.75
MgO	3.00?	2.99	0.02	2	3.00	2.97
CaO	1.35?	1.38	0.06	2	1.42	1.33
Na_2O	3.80?	3.88	0.04	2	3.91	3.85
K_2O	3.60?	3.74	0.06	2	3.78	3.70
TiO_2	0.73?	0.61	0.03	2	0.63	0.59
MnO	0.10?	0.10	0	2	0.10	0.10
P_2O_5	?	0.16	0.01	2	0.17	0.15

g. STANDARD: MRG-1

OXIDE	Abbey (1980) Usable Value	Mines & Energy X	S	n	max	min
SiO_2	39.32	38.75	0.17	4	38.9	38.6
Al_2O_3	8.50	8.41	0.14	4	8.50	8.20
Fe_2O_3(total)	17.82	17.79	0.15	4	17.99	17.66
MgO	13.49	13.54	0.13	4	13.67	13.39
CaO	14.77	14.56	0.23	4	14.89	14.38
Na_2O	0.71	0.67	0.02	4	0.70	0.65
K_2O	0.18	0.15	0.01	4	0.16	0.13
TiO_2	3.69	4.22	0.11	4	4.34	4.12
MnO	0.17	0.18	0.01	4	0.18	0.17
P_2O_5	0.06	0.06	0.02	4	0.08	0.03

h. STANDARD: QLD-1

OXIDE	Abbey (1980) Usable Value	Mines & Energy X	S	n	max	min
SiO_2	65.5?	65.2	0.83	4	65.8	64.0
Al_2O_3	16.2?	16.1	0.17	4	16.3	15.9
Fe_2O_3(total)	4.30?	4.33	0.04	4	4.37	4.28
MgO	1.00?	1.03	0.02	4	1.06	1.01
CaO	3.2?	3.22	0.08	4	3.30	3.13
Na_2O	4.20?	4.24	0.03	4	4.29	4.21
K_2O	3.6?	3.83	0.05	4	3.90	3.80
TiO_2	0.62?	0.66	0.02	4	0.68	0.63
MnO	0.09?	0.09	0	4	0.09	0.09
P_2O_5	0.26?	0.23	0.04	4	0.26	0.17

TABLE A-3 (continued):

i. STANDARD: RGM-1

OXIDE	Abbey (1980) Usable Value	Mines & Energy X	S	n	max	min
SiO_2	73.4?	72.35	0.49	2	72.7	72.0
Al_2O_3	13.8?	13.6	0.11	2	13.7	13.55
Fe_2O_3(total)	1.9?	1.78	0.03	2	1.80	1.76
MgO	0.28?	0.30	0.01	2	0.30	0.29
CaO	1.1?	1.22	0.06	2	1.26	1.18
Na_2O	4.1?	4.10	0.02	2	4.11	4.08
K_2O	4.3?	4.47	0.03	2	4.49	4.45
TiO_2	0.27?	0.30	0.01	2	0.31	0.29
MnO	0.04?	0.04	0	2	0.04	0.04
P_2O_5	0.05?	0.04	0.01	2	0.04	0.03

j. STANDARD: SDC-1

OXIDE	Abbey (1980) Usable Value	Mines & Energy X	S	n	max	min
SiO_2	66.0?	65.2	0.42	4	65.8	64.8
Al_2O_3	16.0?	15.55	0.09	4	15.65	15.45
Fe_2O_3(total)	6.90?	6.89	0.06	4	6.95	6.82
MgO	1.70?	1.70	0.02	4	1.72	1.68
CaO	1.40?	1.43	0.03	4	1.47	1.39
Na_2O	2.0?	2.09	0.01	4	2.10	2.08
K_2O	3.3?	3.39	0.03	4	3.42	3.35
TiO_2	1.0?	1.01	0.04	4	1.04	0.96
MnO	0.12?	0.11	0.01	4	0.12	0.11
P_2O_5	0.17?	0.12	0.03	4	0.15	0.17

k. STANDARD: SCO-1

OXIDE	Abbey (1980) Usable Value	Mines & Energy X	S	n	max	min
SiO_2	62.8?	62.0	0.26	3	62.2	61.7
Al_2O_3	13.6?	13.7	0.09	3	13.80	13.65
Fe_2O_3(total)	5.1?	5.07	0.05	3	5.10	5.02
MgO	2.6?	2.68	0.05	3	2.73	2.65
CaO	2.6?	2.55	0.02	3	2.57	2.53
Na_2O	0.9?	0.93	0.01	3	0.93	0.92
K_2O	2.7?	2.72	0.03	3	2.75	2.69
TiO_2	0.64	0.55	0.02	3	0.56	0.53
MnO	0.05?	0.05	0	3	0.05	0.05
P_2O_5	0.44?	0.21	0.02	3	0.22	0.18

TABLE A-3 (continued):

l. STANDARD: STM-1

	Abbey (1980)	Mines & Energy				
OXIDE	Usable Value	X	S	n	max	min
SiO_2	59.5?	59.8	0.35	2	60.0	59.5
Al_2O_3	18.5?	18.6	0	2	18.6	18.6
Fe_2O_3(total)	5.2?	5.27	0.06	2	5.31	5.22
MgO	0.10?	0.11	0.01	2	0.12	0.10
CaO	1.1?	1.10	0	2	1.10	1.10
Na_2O	9.0?	9.05	0.05	2	9.08	9.01
K_2O	4.30?	4.48	0.01	2	4.49	4.47
TiO_2	0.13?	0.14	0.01	2	0.14	0.13
MnO	0.22?	0.23	0	2	0.23	0.23
P_2O_5	0.16?	0.16	0.02	2	0.17	0.14

m. STANDARD: SY-2

	Abbey (1980)	Mines & Energy				
OXIDE	Usable Value	X	S	n	max	min
SiO_2	60.10	59.9	0.60	4	60.8	59.9
Al_2O_3	12.12	12.25	0.10	4	12.35	12.15
Fe_2O_3(total)	6.28	6.27	0.10	4	6.38	6.14
MgO	2.70	2.67	0.05	4	2.73	2.61
CaO	7.98	7.96	0.13	4	8.03	7.76
Na_2O	4.34	4.33	0.03	4	4.36	4.29
K_2O	4.48	4.63	0.14	4	4.80	4.47
TiO_2	0.14	0.15	0.01	4	0.16	0.14
MnO	0.32	0.34	0.02	4	0.36	0.32
P_2O_5	0.43	0.43	0.03	4	0.46	0.41

TABLE A-4: **ACCURACY OF TRACE ELEMENT DETERMINATIONS BY X.R.F. Memorial University of Newfoundland.**

Notes:
X: mean of determinations
S: standard deviation
n: number of determinations
max: maximum value obtained
min: minimum value obtained

a. Standard: W-1

	Usable Value (Abbey, 1980)	XRF X	S	n	max	min
Nb	9.5	5.5	1.2	6	7	4
Zr	105	88.3	1.4	6	90	87
Y	25	28.5	1.2	6	30	27
Sr	190	188.5	1.2	6	190	187
Rb	21	21.3	1.0	6	22	20
U	0.58	1.0	1.3	6	3	0
Th	2.4	5.8	1.2	6	7	4
Pb	7.8	9.8	2.3	6	12	7
Ga	16	12.2	1.5	6	14	10
Zn	86	78.3	1.8	6	81	76
Ni	76?	74.7	2.1	6	77	72
Cu	110	105.3	3.4	6	111	102
Cr	115?	106.8	6.9	6	112	98
V	260	256.0	1.8	6	259	254
Ce	23?	12.2	2.1	6	15	9
La	9.8?	14.0	1.8	6	17	12
Ba	160	154.5	12.4	6	167	154

b. Standard: G-2

	Usable Value (Abbey, 1980)	XRF X	S	n	max	min
Nb	13?	12.7	1.0	24	15	11
Zr	300	305.2	2.3	24	311	302
Y	11	12.5	.9	24	15	11
Sr	480	473.8	3.4	24	479	465
Rb	170	167.6	1.2	24	171	166
U	2.1	1.6	0.7	24	3	0
Th	25	25.0	1.4	24	27	23
Pb	30	30.0	1.4	24	33	28
Ga	23	22.4	1.8	24	24	9
Zn	84	77.8	3.2	24	83	70
Ni	3.5	16.1	4.1	24	22	10
Cu	10	12.9	4.3	24	24	4
Cr	8	8.0	3.7	8	12	1
V	36	35.8	2.7	24	41	32
Ce	160	175.0	18.7	24	211	153
La	92	94.3	8.0	24	107	80
Ba	1900	1825	16.7	24	1867	1794

TABLE A-4 (continued):

c. Standard: ECR-1

	Usable Value (Abbey, 1980)	XRF X	S	n	max	min
Nb	19?	11.7	1.7	3	13.6	10.5
Zr	185	184.0	4.4	3	187	179
Y	40	46.7	2.5	3	49	44
Sr	330	329.3	8.0	3	336	320
Rb	47	46.0	1.7	3	47	44
U	1.7	1.1	0.9	3	2	0.2
Th	6.1	7.3	2.5	3	10	5
Pb	14	15.7	1.5	3	17	14
Ga	22	19.3	2.1	3	21	17
Zn	125	111.7	4.2	3	115	107
Ni	10	32.0	2.6	3	35	30
Cu	16	12.0	1.0	3	13	11
V	420	418.3	3.2	3	422	416
Ce	53	72.3	14.0	3	88	61
La	27	28.7	10.0	3	40	21
Ba	600	702.0	9.0	3	711	693

d. Standard: AGV-1

	Usable Value (Abbey, 1980)	XRF X	S	n	max	min
Nb	16	15	0	2	15	15
Zr	230	231	0	2	231	231
Y	19	26.5	0.7	2	27	26
Sr	660	673	4.2	2	676	670
Rb	67	68.5	0.7	2	69	68
U	1.95	1.2	1.1	2	2	0.4
Th	6.4	5.5	0.7	2	6	5
Pb	33	34	0	2	34	34
Ga	19	20.5	0.7	2	21	20
Zn	86	80	1.4	2	81	79
Ni	15	18.5	4.9	2	22	15
Cu	59	60	2.8	2	52	58
V	125	127	1.4	2	128	126
Ce	71	75	2.8	2	77	73
La	36	40	4.2	2	43	37
Ba	1200	1178.5	3.5	2	1181	1176

TABLE A-4 (continued):

e. Standard: GSP-1

	Usable Value (Abbey, 1980)	XRF X	S	n	max	min
Nb	23?	36	0	3	36	36
Zr	500	498.3	4.5	3	503	494
Y	29	34.5	0.7	3	34	37
Sr	240	235	2.0	3	233	237
Rb	250	255	1.0	3	254	256
U	2.1	2.7	1.2	3	4	2
Th	105	96.3	1.2	3	97	95
Pb	54	56.7	2.3	3	58	54
Ga	23	22	3.0	3	25	19
Zn	98	92.7	5.7	3	99	88
Ni	9	24.3	1.2	3	25	23
Cu	33	39.0	12.1	3	46	25
Cr	12	3.7	4.6	3	9	1
V	54	51.0	1.0	3	52	50
Ce	360	263.0	8.7	3	268	253
La	195	138.3	4.5	3	143	134
Ba	1300	1235.0	5.0	3	1240	1230

TABLE A-5: ACCURACY OF TRACE ELEMENT DETERMINATIONS BY A.A. Newfoundland Department of Mines and Energy, Mineral Development Division Laboratory.

a. Standard: SY-2

	Usable Value (Abbey, 1980)	A.A. X	S	n	max	min
Be	23	21.3	1.4	16	24	19
Li	93	76.3	4.8	16	84	69
Mo	3?	2.9	0.77	16	4	2

b. Standard: MRG-1

	Usable Value (Abbey, 1980)	A.A. X	S	n	max	min
Be	0.6	1.1	0.3	17	2	1
Li	4.0	7.2	2.2	17	11	4
Mo	-	4.8	1.8	17	10	3

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